

REMTECH inc.

Huntsville, Alabama

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APPENDIX C

COMPARISON OF INTERFERENCE FACTORS BETWEEN OFT FLIGHT, PREDICTION AND IH-97A TEST DATA

TECHNICAL NOTE

TITLE: Comparison Of Interference Factors Between OFT Flight,
Prediction and IH-97A Test Data
(From RTN 041-15)
DATE: July 26, 1983
AUTHOR: Dr. Sarat C. Praharaj and Donald R. Hulsey
CONTRACT NO: NAS8-33373
PREPARED FOR: George C. Marshall Space Flight Center

DESCRIPTION

The purpose of this note is to present the OTS turbulent interference factor (h_i/h_u) - Mach number plots comparing OFT flight data, prediction and IH-97A data. They are given in the following four sets of plots which are attached as Appendix to this note:

Set 1 -	STS-1	pp. 1.1 - 1.21
Set 2 -	STS-2	pp. 2.1 - 2.34
Set 3 -	STS-3	pp. 3.1 - 3.34
Set 4 -	STS-4	pp. 4.1 - 4.36

A typical plot compares h_i/h_u data derived from flight, h_i/h_u prediction based on the wind tunnel data base, and h_i/h_u data obtained from test IH-97A. The data reduction procedure for the flight data is documented elsewhere (Ref. 1). The prediction procedure is described in detail for STS-1 in Ref. 2. As far as the ET acreage data in test IH-97A, the tabulated data are reported in Ref. 3. It should be emphasized that Ref. 3 contains only the acreage h_i/h_u data and not the protuberance h_i/h_u data. For ease of the user, the h_i/h_u data from test IH-97A for the acreage DFI locations are summarized in Tables *.1 and *.2 for each of the STS flights. The gages 9017 (Island 12), 9018 (117), 9022 (123),

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9001, 9042, 9045, 9046, and 9047 were remodeled for flights beyond STS-1 by using the observed flight data from STS-1. So care should be exercised before using the predicted h_i/h_u in the STS-1 mission. The protuberance data are being worked elsewhere and have not yet been documented fully. As a consequence, the plots for acreage DFI locations contain the h_i/h_u data from flight, wind tunnel data base and IH-97A test, whereas the plots pertaining to protuberance gages contain only the flight and prediction interference factors. It should further be cautioned to the user that for the h_i/h_u data pertaining to the protuberance gages located on the A-frame and the aft attach structure, the undisturbed value of the convective film coefficient (h_u) is based on the flat-plate value calculated on the ET skin. It could easily be changed to the corresponding undisturbed value on the protuberance by a multiplier while considering the turbulent regime.

REFERENCES

1. Praharaj, S. C. and Engel, C. E., "STS Orbital Flight Test (OFT) External Tank Aerothermal Flight Evaluation," REMTECH, Inc., Huntsville, Alabama, Technical Report (Under Preparation).
2. Praharaj, S. C. and Engel, C. E., "STS-1 ET Aerothermal Flight Evaluation," REMTECH, Inc., Huntsville, Alabama, Technical Report 041-1, April 1982.
3. Somers, R. E., and Warmbrod, J. D., "External Tank Acreage Heat Transfer Data Tables For Test IH-97A," REMTECH, Inc., Huntsville, Alabama, Report RM 032-7, March 1983.

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APPENDIX

SET - 1

STS-1 pp. 1.1 - 1.21

Table 1.1 STS-1 DFI LOCATIONS

MEASUREMENT I.D.	XT (IN.)	THETA (DEG.)	GAGE TYPE	LOCATION
T07R9001A	350.0	180.0	Ind. Gage	40° Cone
T07R9011A	976.0	25.0	Island 18	Intertank
T07R9012A	1008.0	21.0	Ind. Gage	L02 Fdin. Fairing (side)
T07R9013A	1110.4	2.5	Island 17(3)	Intertank
T07R9014A	937.4	288.6	Island 16	Intertank
T07R9015A	956.2	270.0	Island 15	Intertank
T07R9016A	937.4	251.4	Island 14	Intertank
T07R9017A	948.5	180.0	Island 12	Intertank
T07R9018A	1098.5	2.5	Island 17(2)	Intertank
T07R9019A	1084.4	2.5	Island 17(1)	Intertank
T07R9021A	1030.1	270.0	Island 20	Intertank
T07R9022A	1073.8	180.0	Island 23	Intertank
T07R9038A	996.0	23.0	Ind. Gage	L02 Fdin Fairing (top)
T07R9039A	1129.9	356.0	Ind. Gage	ET/ORB Fwd LH Strut
T07R9041A	959.2	270.0	Ind. Gage	Bolt Catcher
T07R9042A	2002.0	29.0	Ind. Gage	RH Thrust Strut
T07R9045A	2058.0	10.0	Ind. Gage	Aft Diag. Strut
T07R9046A	2100.0	45.0	Ind. Gage	LH Vert Strut Cable Tray
T07R9047A	2035.0	26.0	Ind. Gage	Fwd. L02 Fdin/X-Beam Cable Tray

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Table 1.2

STS-1 ET INTERFERENCE FACTORS FROM THE IH-97A WIND TUNNEL DATA BASE

FLIGHT GAGE NO.	IH97A GAGE NO.	HI/HU @ MACH NUMBER						
		2.25	2.50	2.75	3.00	3.25	3.50	3.75
9001	5029	1.100	1.158	1.079	1.587	1.951	2.141	2.115
9017	5035	0.625	0.663	0.615	0.745	0.730	0.730	0.756
9016	5036	4.836	4.812	5.128	4.843	4.727	5.250	5.235
9015	5258	5.763	6.256	7.485	8.476	8.344	9.249	10.618
9014	5038	3.456	3.205	3.329	3.634	4.420	5.222	5.559
9011	5042	1.289	1.185	1.051	0.870	0.911	0.833	0.926
9021	5043	0.098	0.289	0.341	0.479	0.692	1.823	1.872
9019	5040	2.858	3.026	3.318	3.365	—	2.434	2.216
9018	5039	3.237	3.562	3.997	4.364	3.630	3.386	3.157
9013	5041	—	—	—	4.677	—	4.043	3.561

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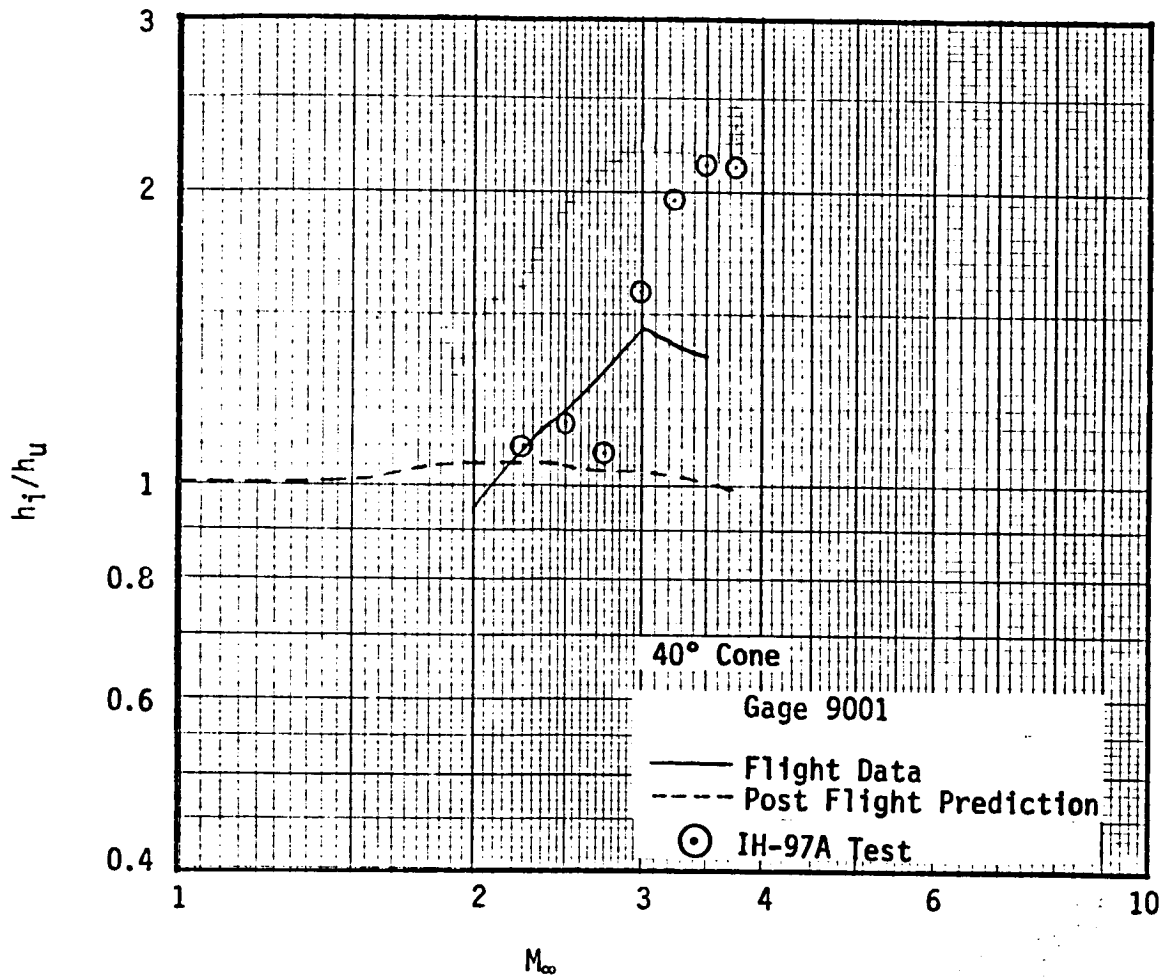


Fig. 1.1 STS-1 Post Flight Interference Factors for Gage 9001

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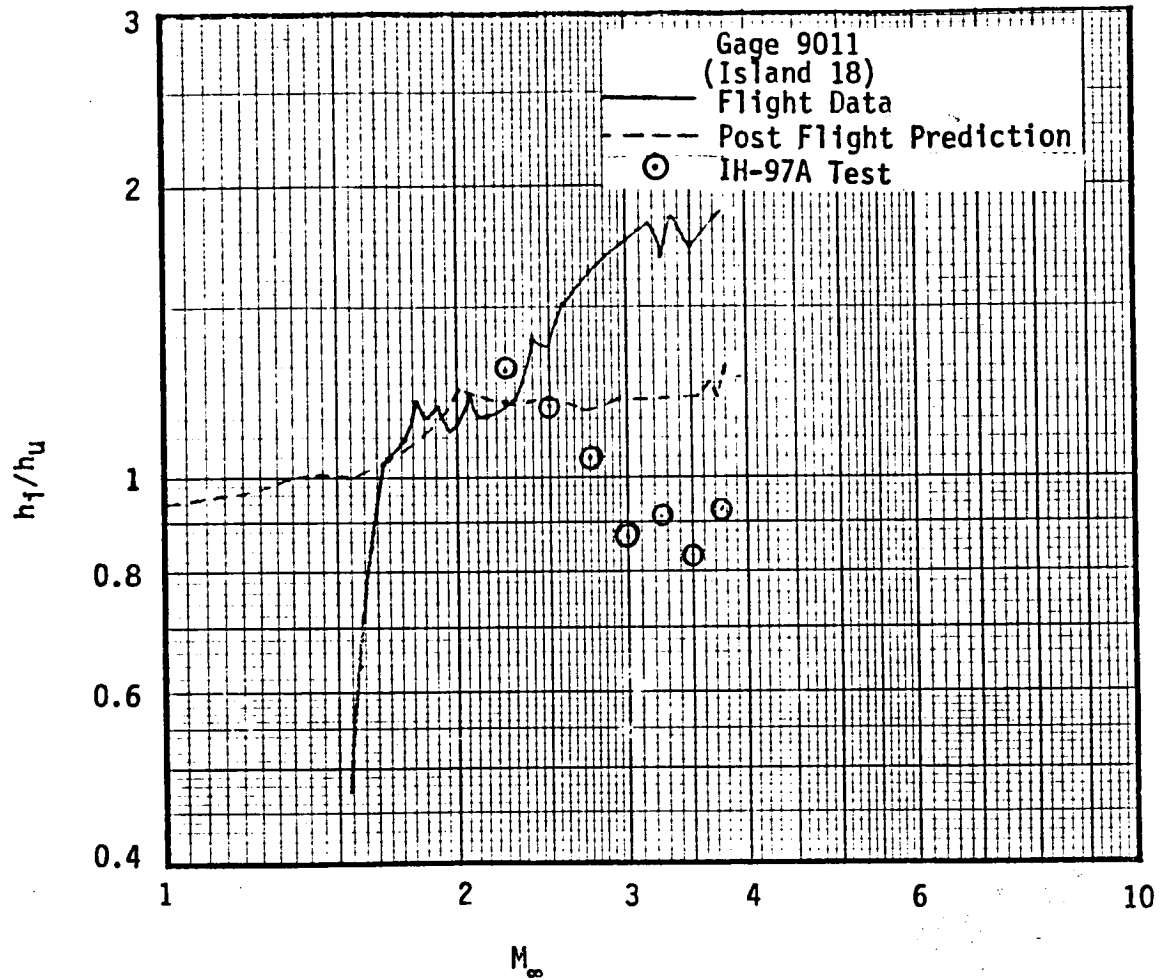


Fig. 1.2 STS-1 Post Flight Interference Factors for Gage 9011

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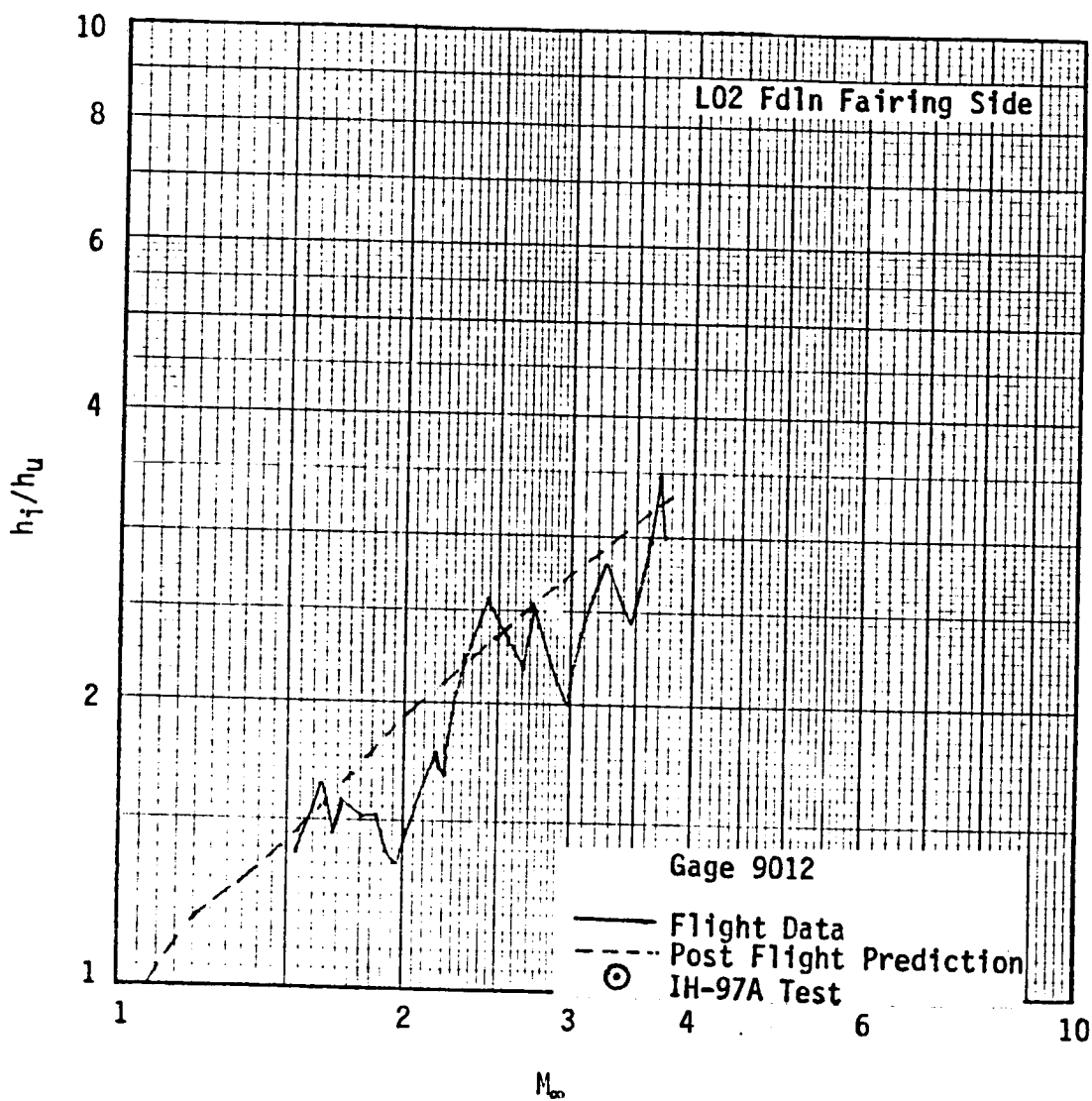


Fig. 1.3 STS-1 Post Flight Interference Factors for Gage 9012

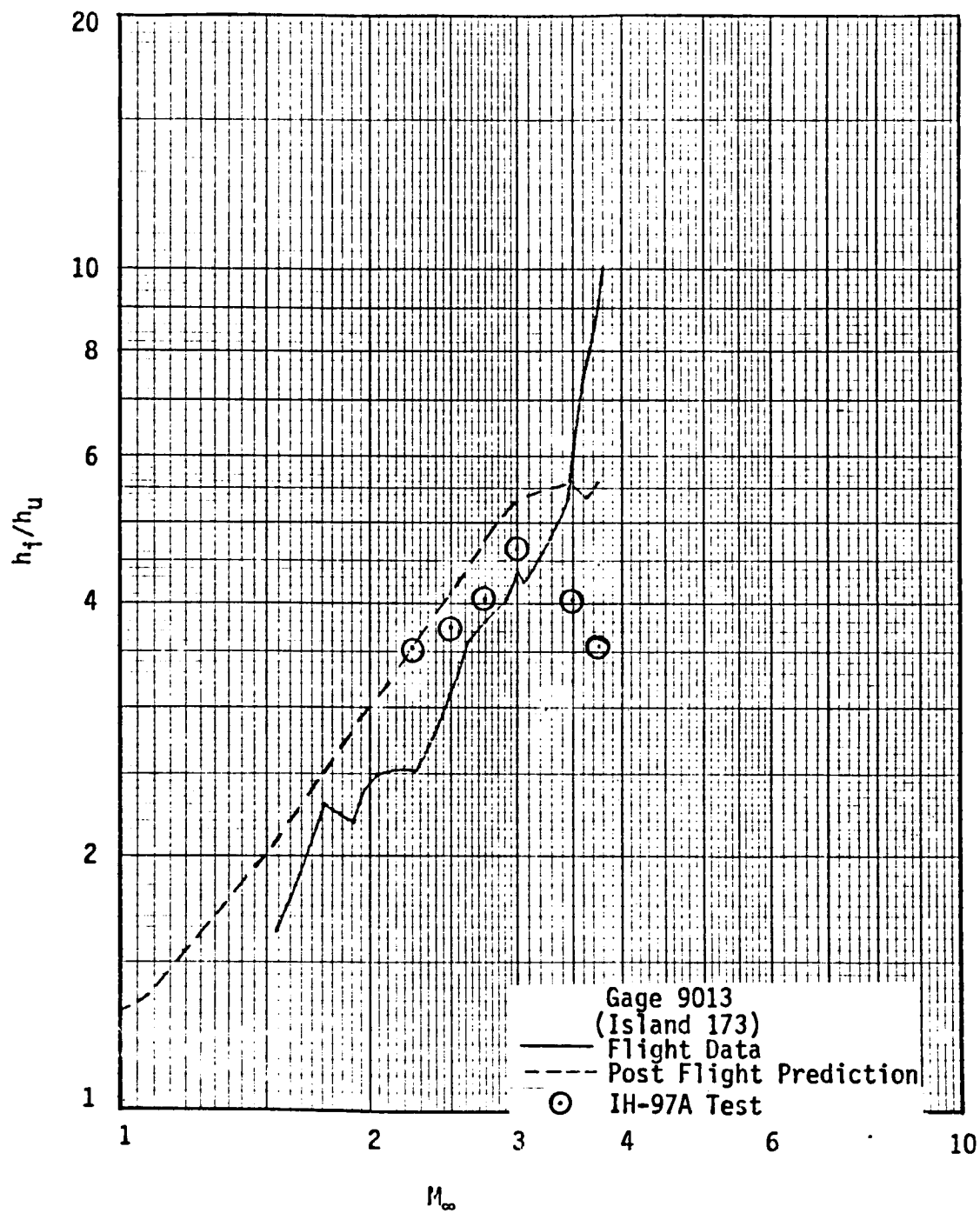


Fig. 1.4 STS-1 Post Flight Interference Factors for Gage 9013

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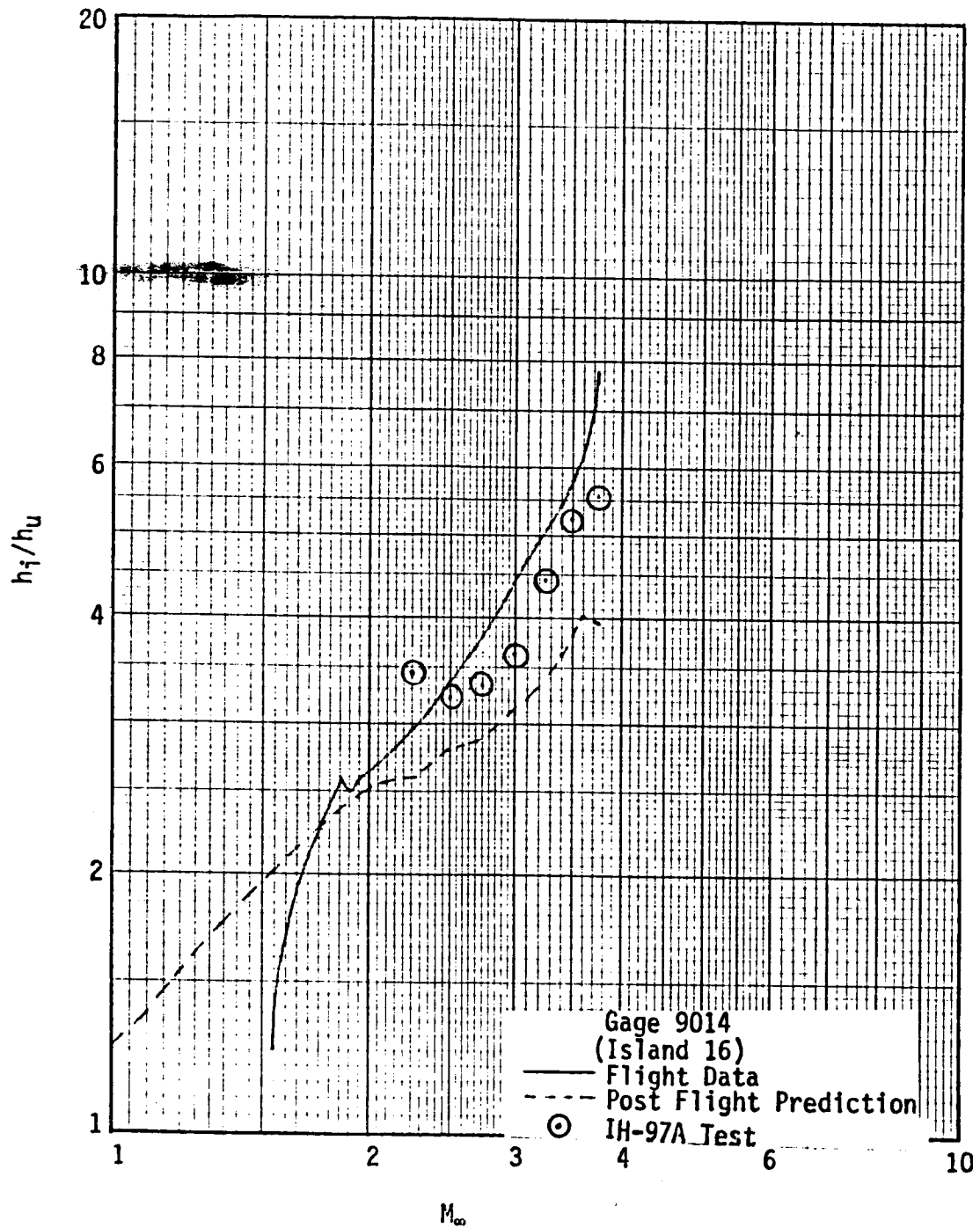


Fig. 1.5 STS-1 Post Flight Interference Factors for Gage 9014

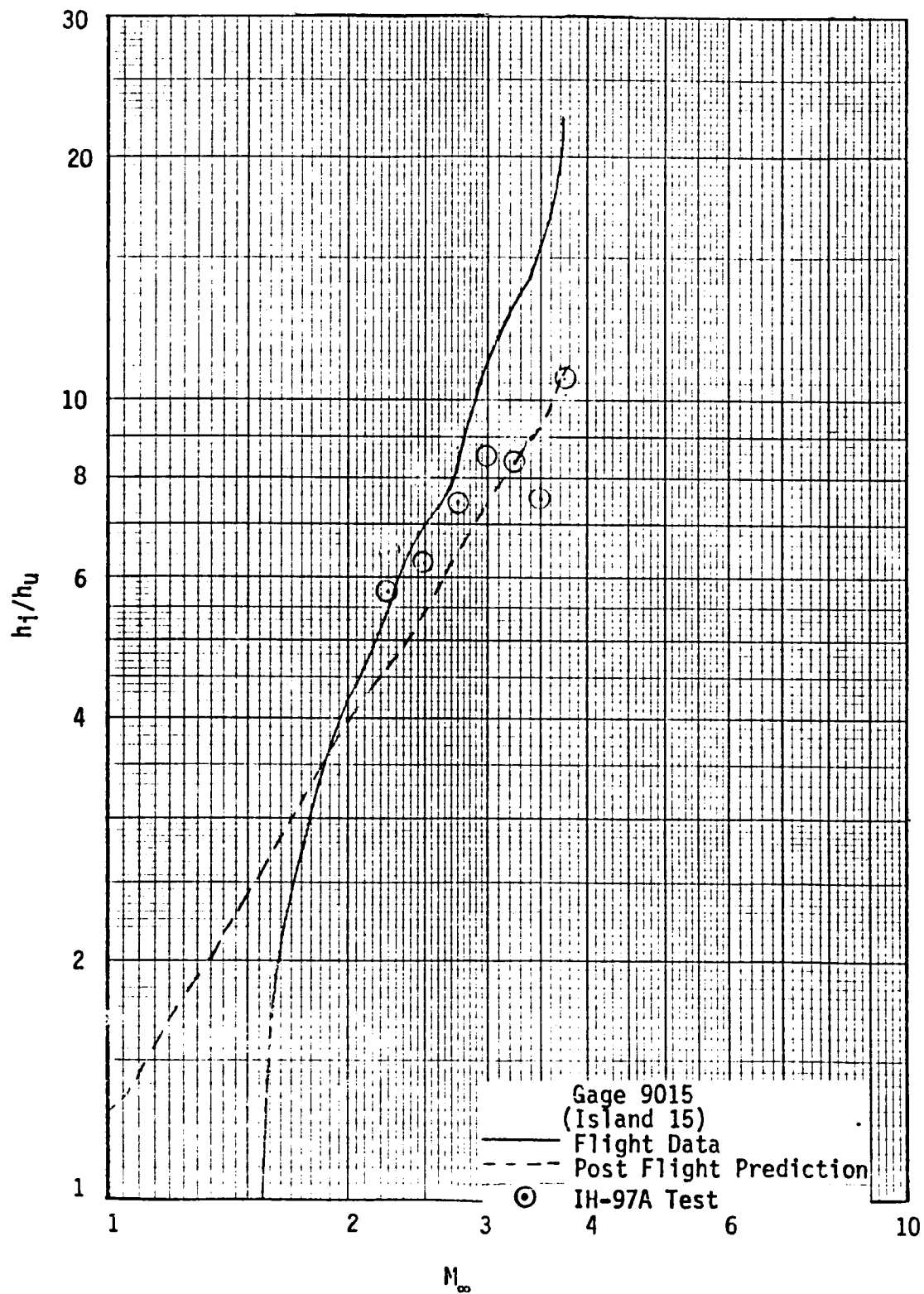


Fig. 1.6 STS-1 Post Flight Interference Factors for Gage 9015

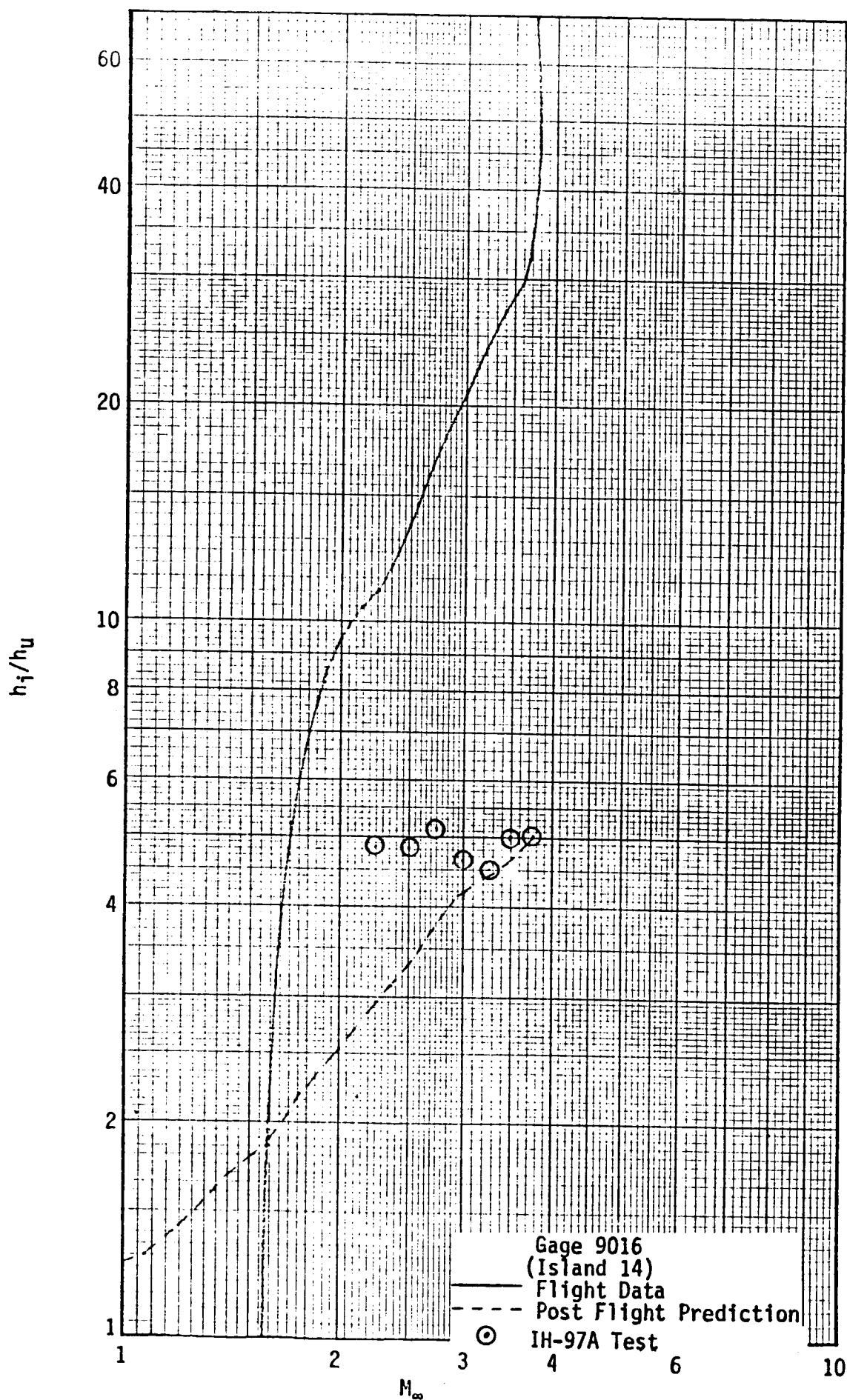


Fig. 1.7 STS-1 Post Flight Interference Factors for Gage 9016

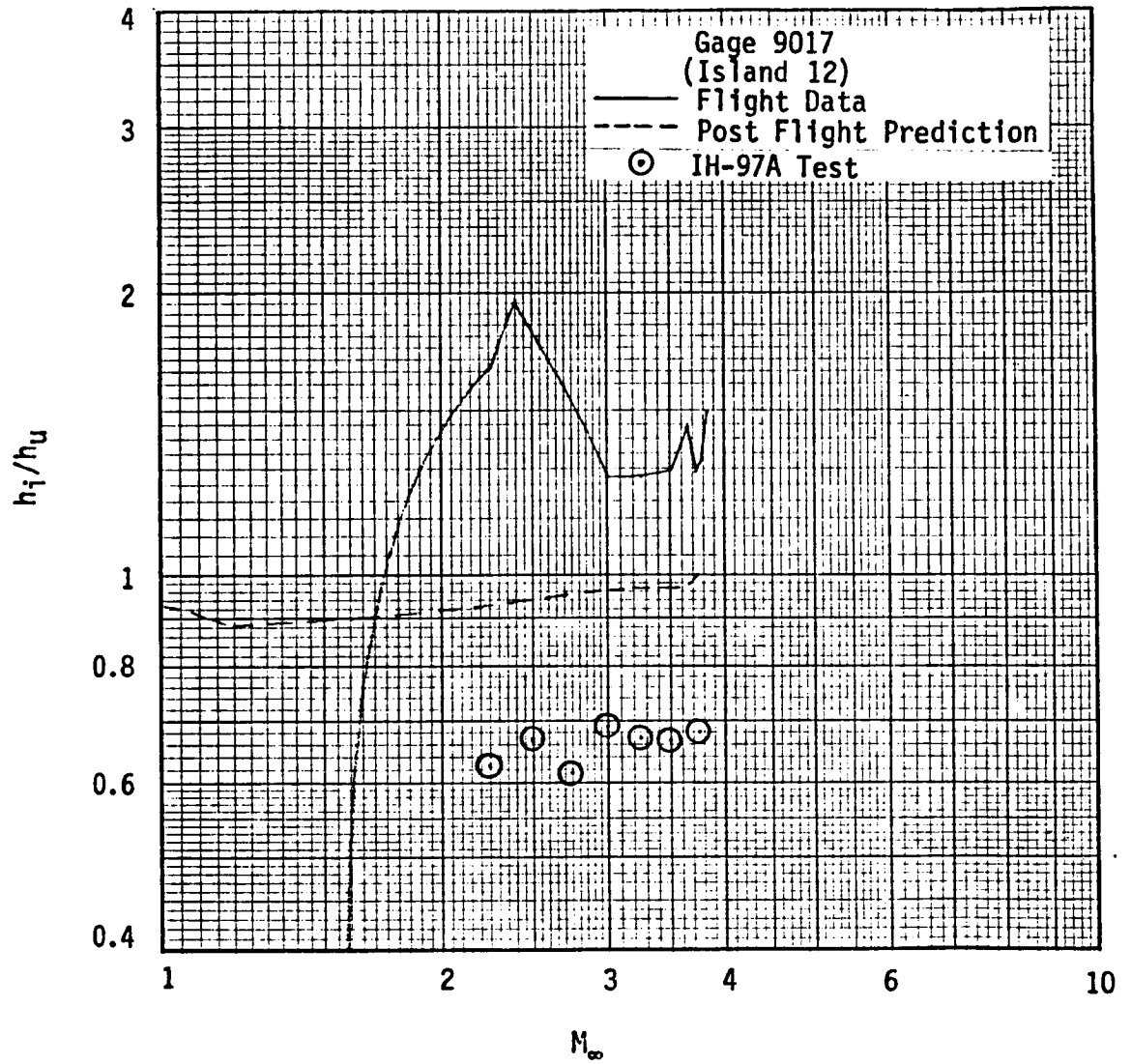


Fig. 1.8 STS-1 Post Flight Interference Factors for Gage 9017

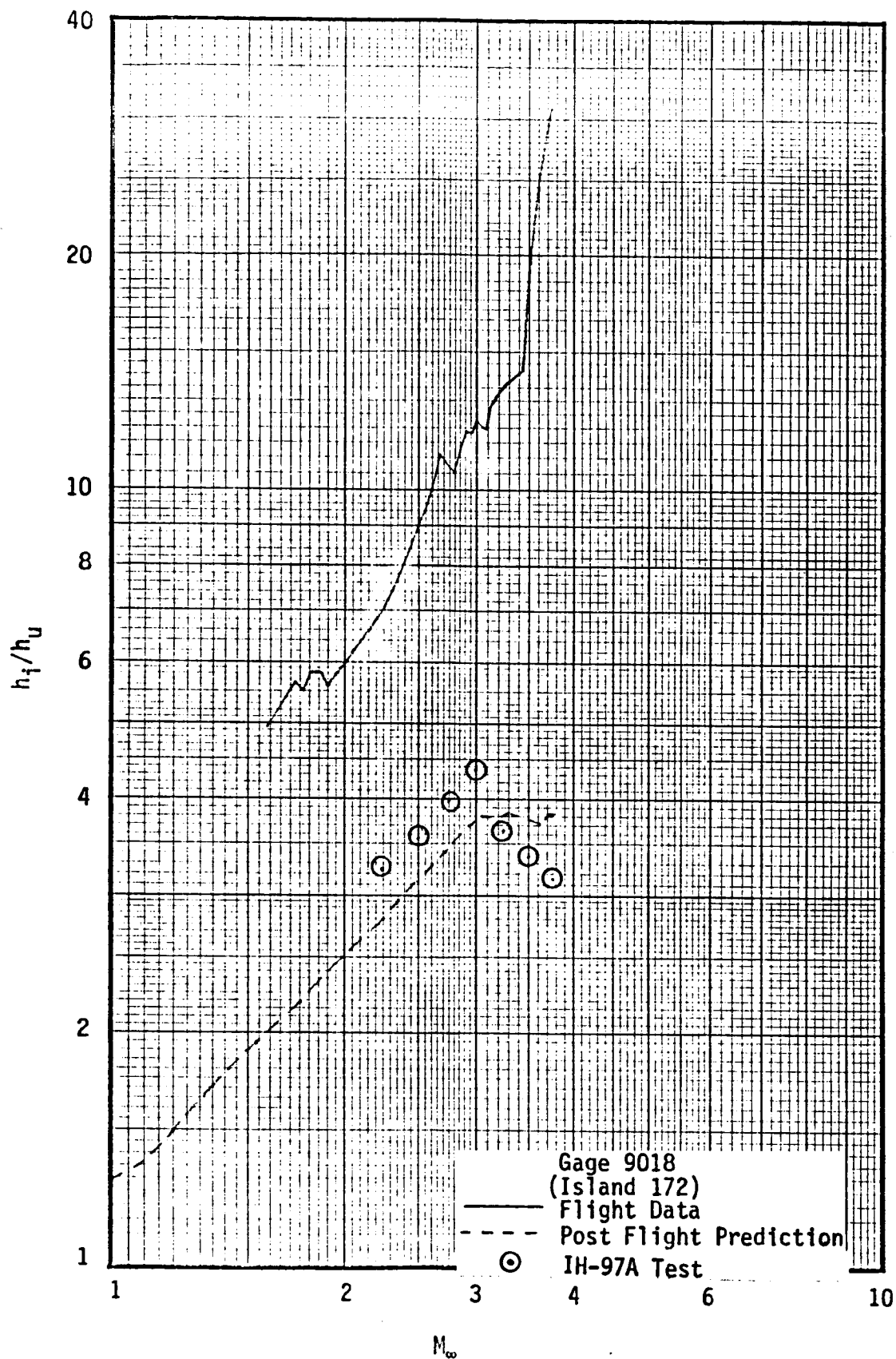


Fig. 1.9 STS-1 Post Flight Interference Factors for Gage 9018

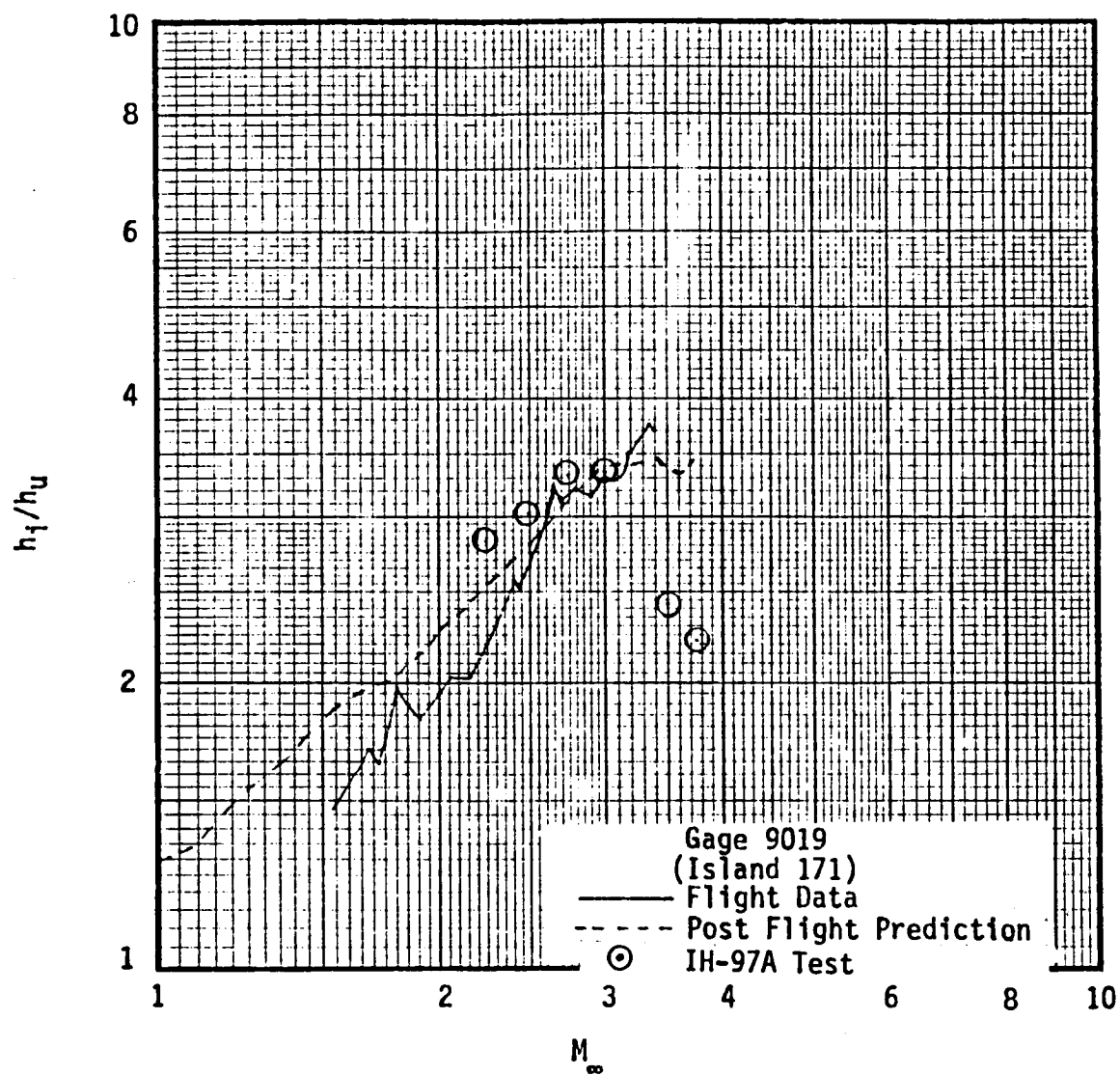


Fig. 1.10 STS-1 Post Flight Interference Factors for Gage 9019

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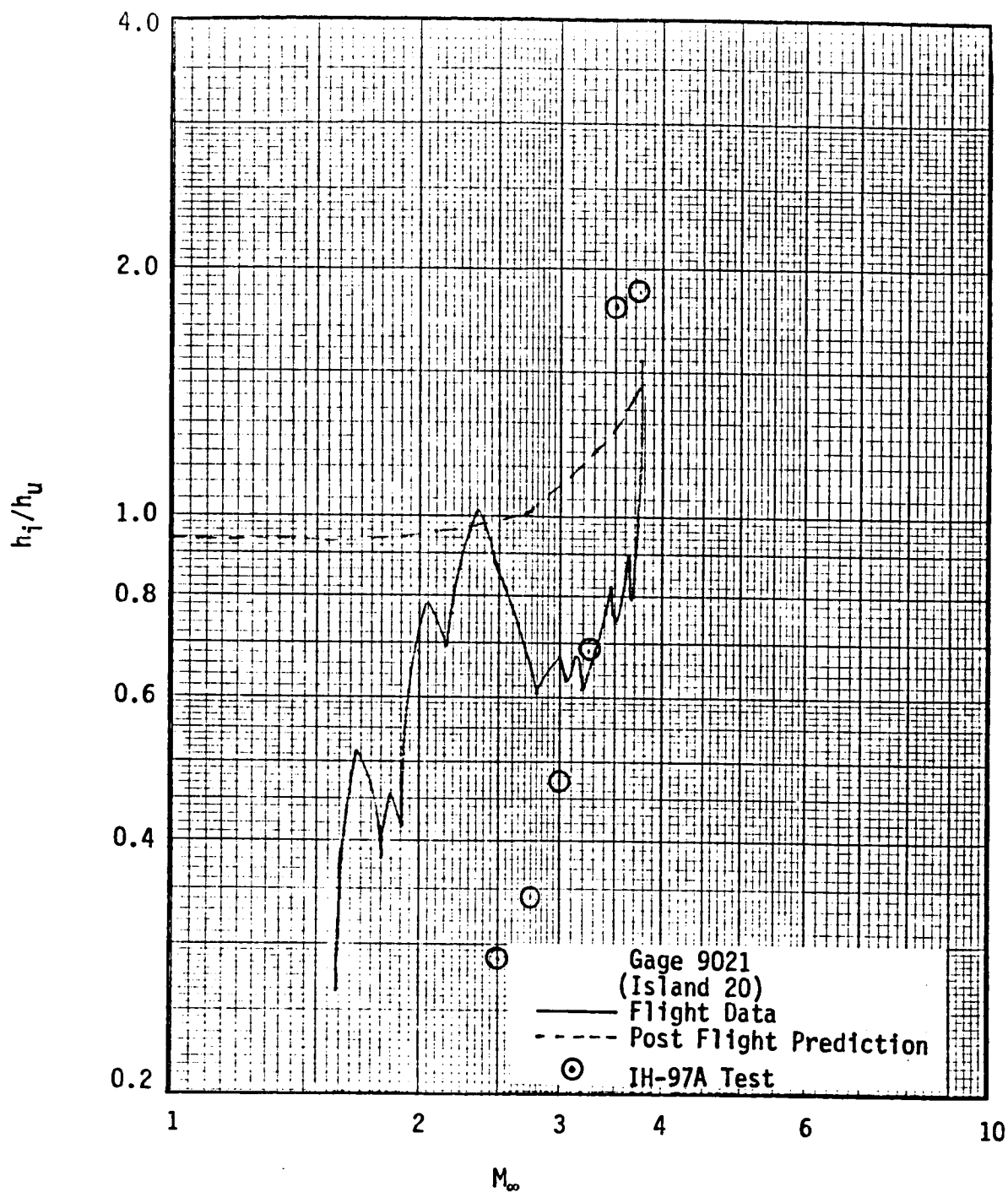


Fig. 1.11 STS-1 Post Flight Interference Factors for Gage 9021

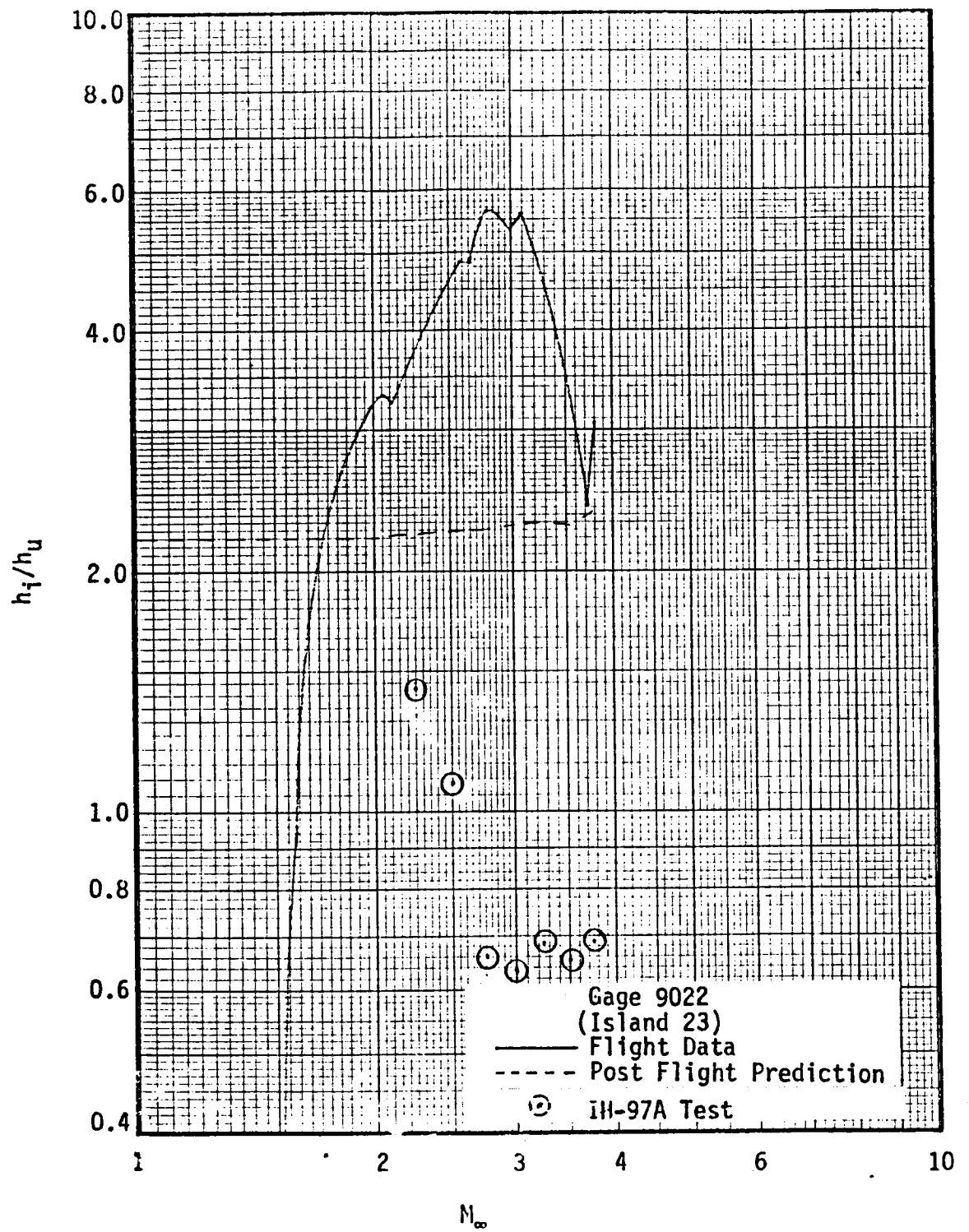


Fig. 1.12 STS-2 Post Flight Interference Factors for Gage 9022

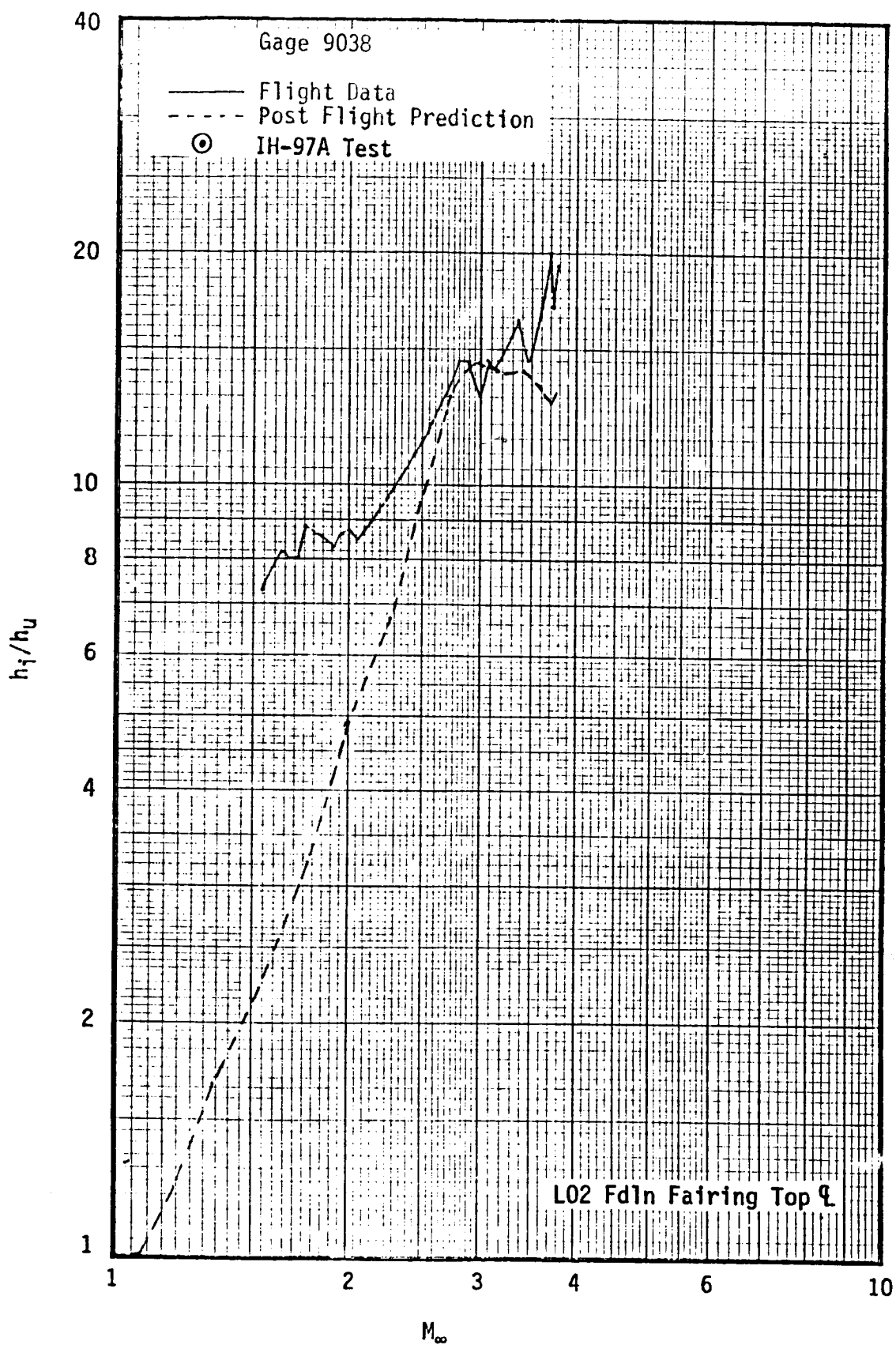


Fig. 1.13 STS-1 Post Flight Interference Factors for Gage 9038

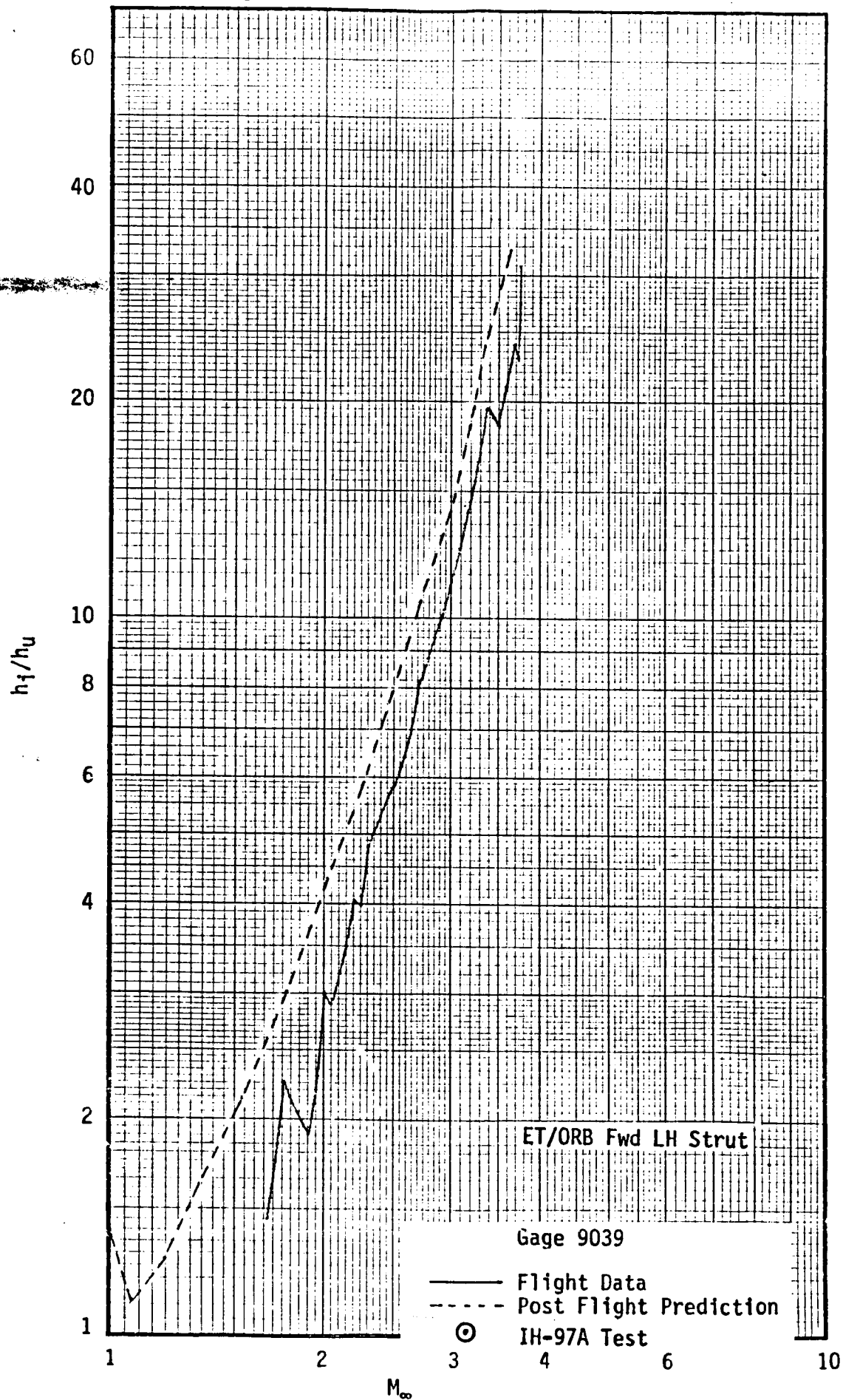


Fig. 1.14 STS-1 Post Flight Interference Factors for Gage 9039

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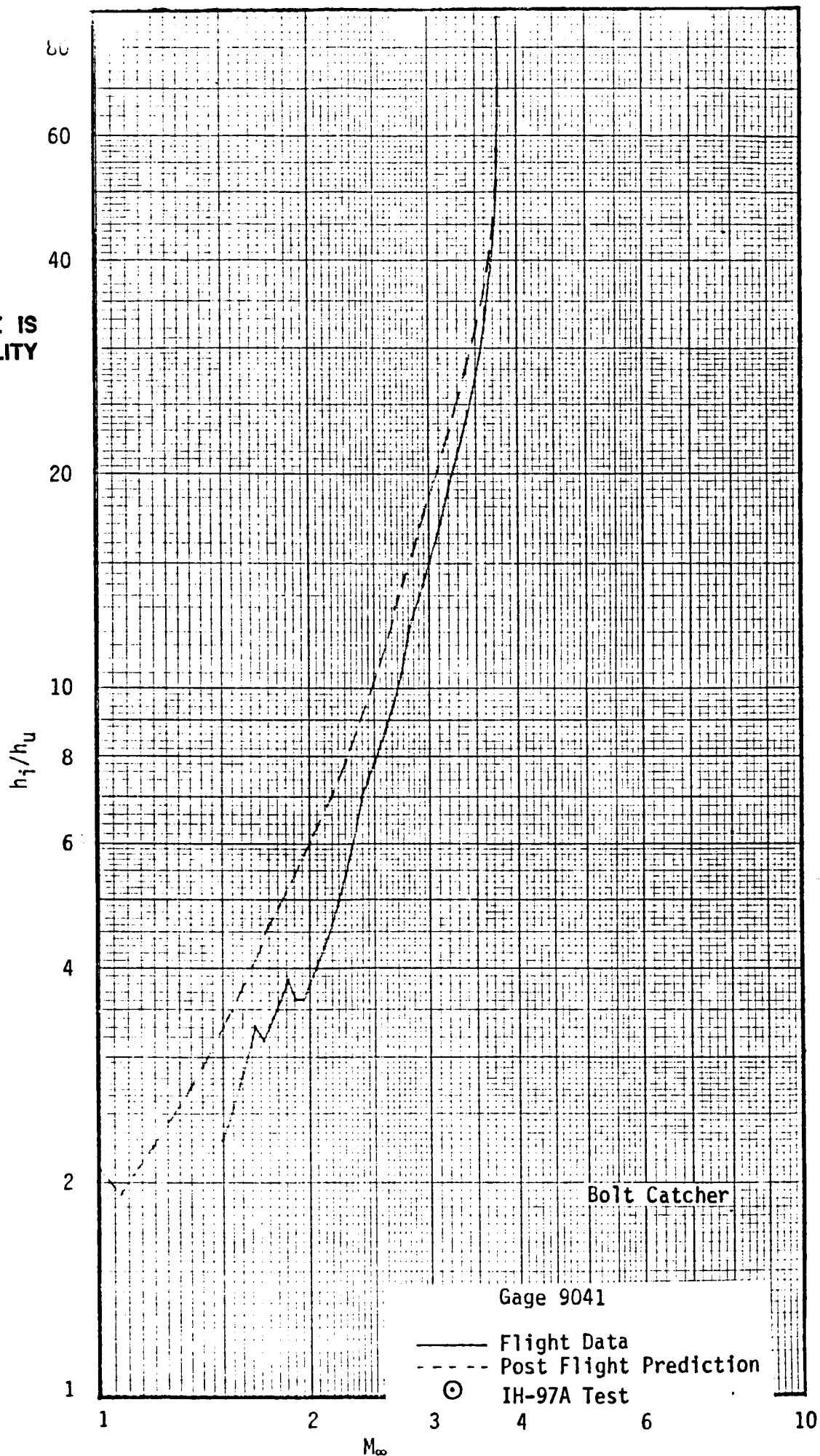


Fig. 1.15 STS-1 Post Flight Interference Factors for Gage 9041

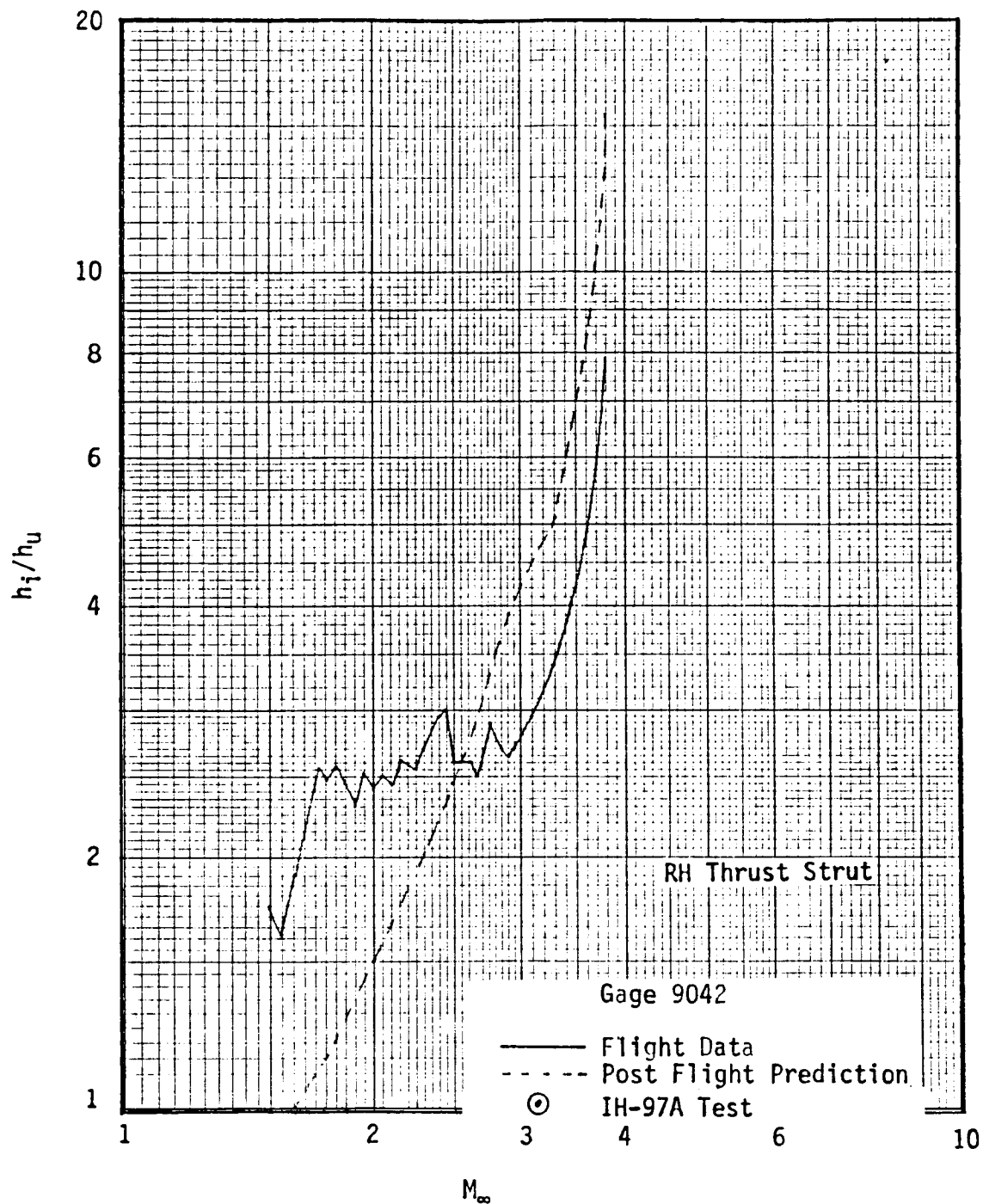


Fig. 1.16 STS-1 Post Flight Interference Factors for Gage 9042

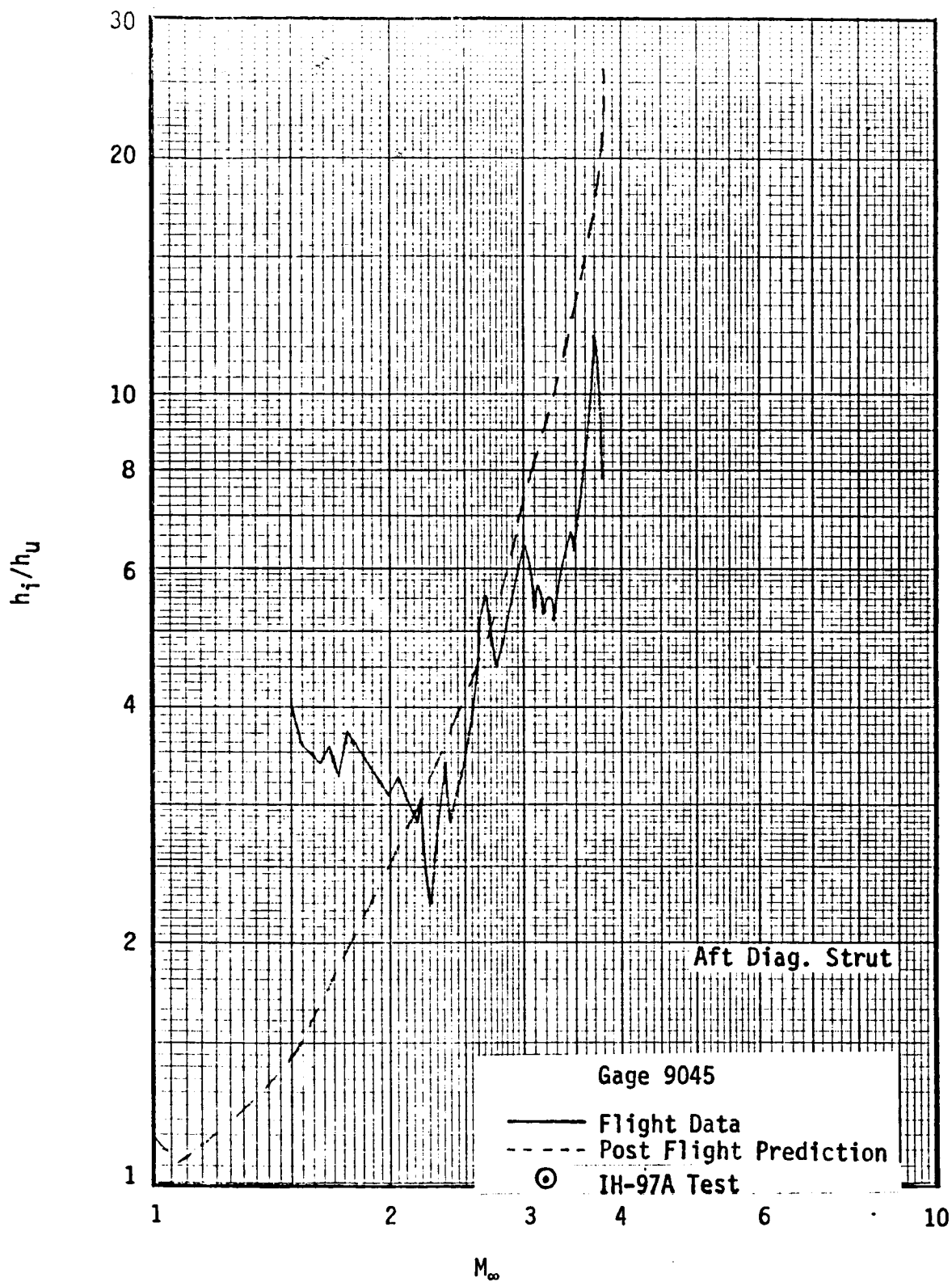


Fig. 1.17 STS-1 Post Flight Interference Factors for Gage 9045

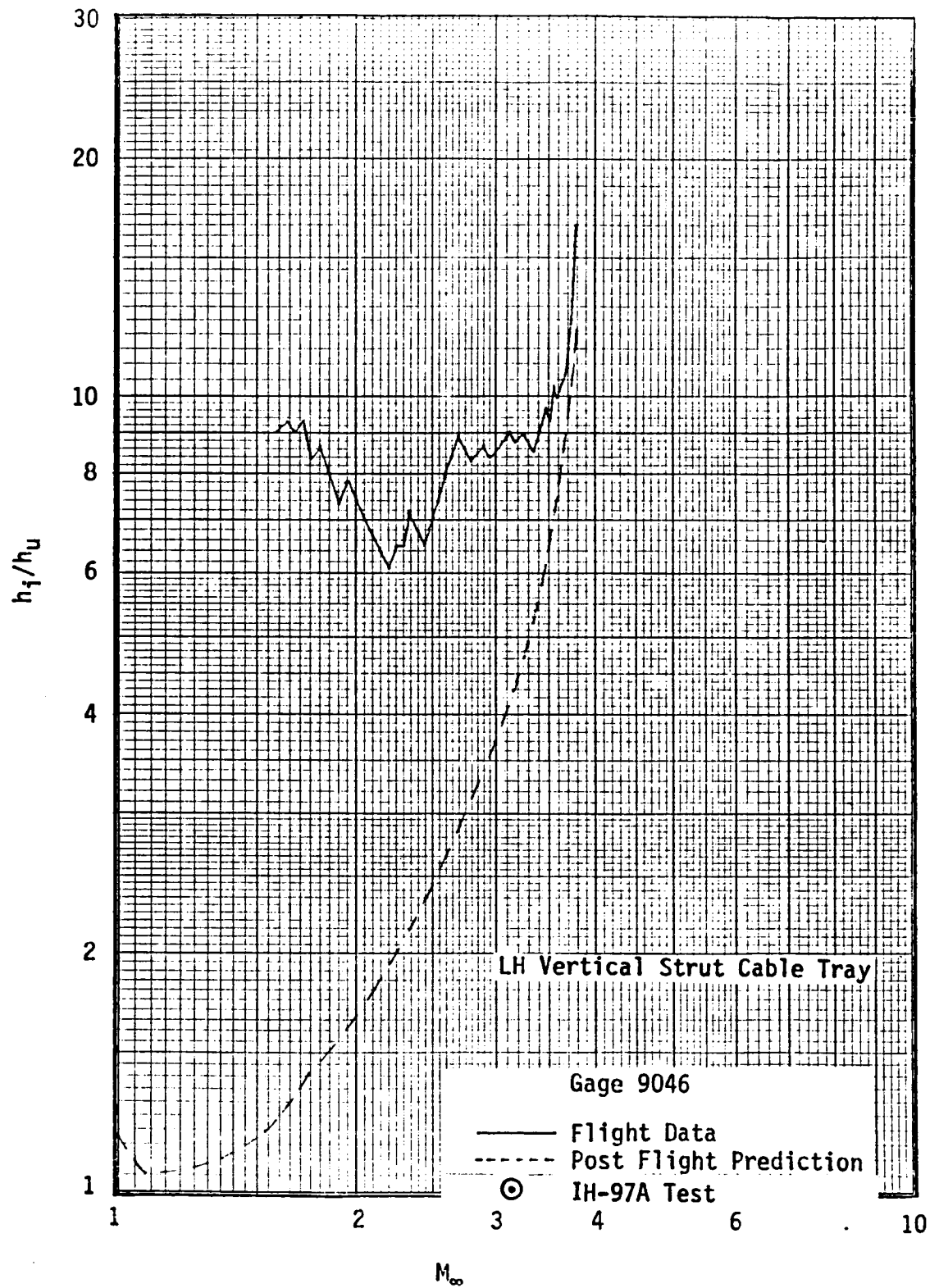


Fig. 1.18 STS-1 Post Flight Interference Factors for Gage 9046

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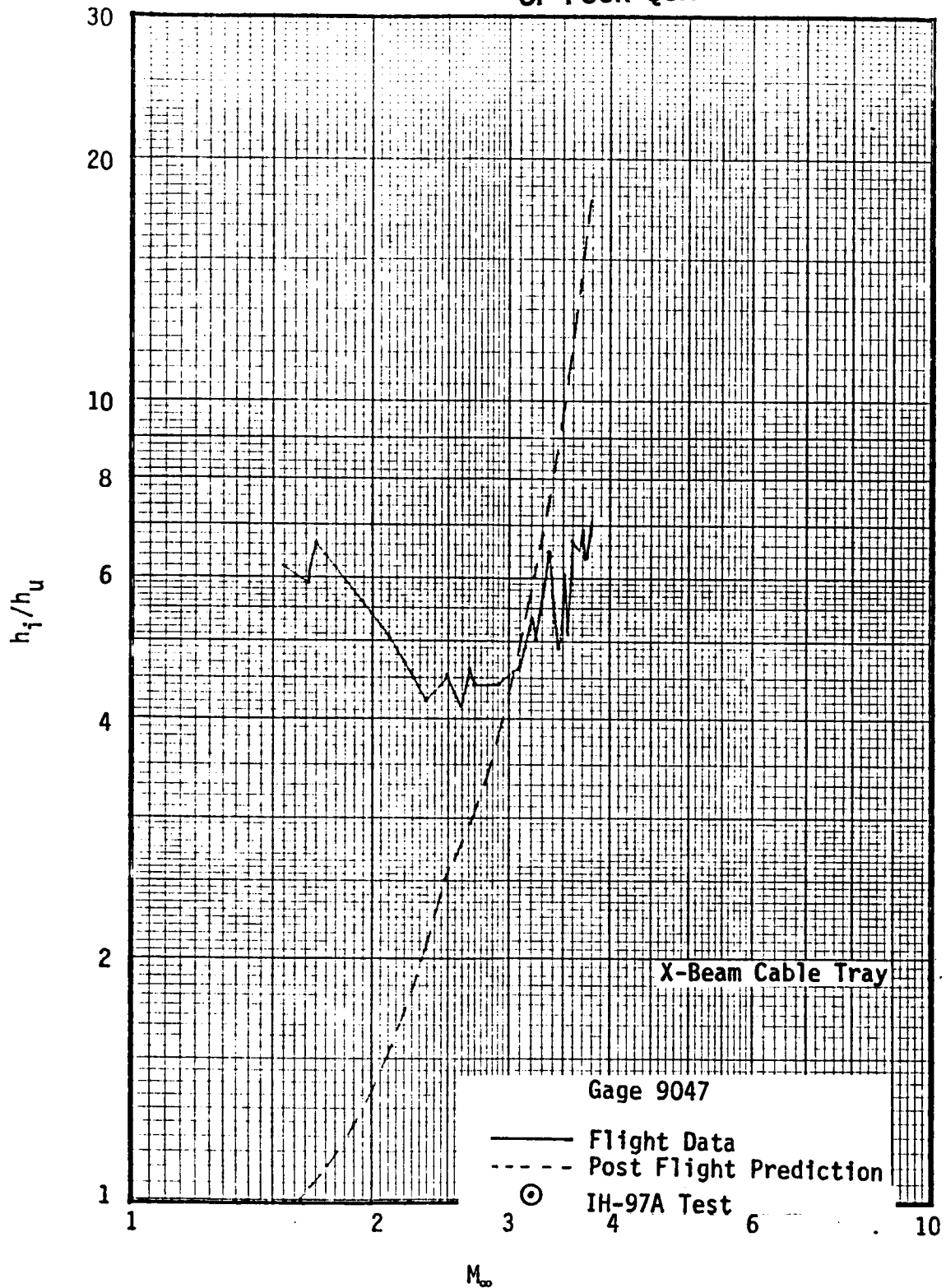


Fig. 1.19 STS-1 Post Flight Interference Factors for Gage 9047

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SET 2

STS-2 pp. 2.1 - 2.34

Table 2.1 STS-2 DFI LOCATIONS

MEASUREMENT I.D.	XT (IN.)	THETA (DEG.)	GAGE TYPE	LOCATION
T07R9001A	350.0	180.0	Ind. Gage	40° Cone
T07R9004A	467.4	264.0	Island 2	L02 Tank
T07R9005A	467.4	174.0	Island 1	L02 Tank
T07R9007A	672.5	270.0	Island 6	L02 Tank
T07R9008A	672.5	180.0	Island 5	L02 Tank
T07R9010A	825.5	270.0	Island 8	L02 Tank
T07R9011A	976.0	25.0	Island 18	Intertank
T07R9012A	1008.0	21.0	Ind. Gage	L02 Fdln. Fairing (side)
T07R9013A	1110.4	2.5	Island 17(3)	Intertank
T07R9014A	937.4	288.6	Island 16	Intertank
T07R9015A	956.2	270.0	Island 15	Intertank
T07R9016A	937.4	251.4	Island 14	Intertank
T07R9017A	948.5	180.0	Island 12	Intertank
T07R9018A	1098.5	2.5	Island 17(2)	Intertank
T07R9019A	1084.4	2.5	Island 17(1)	Intertank
T07R9021A	1030.1	270.0	Island 20	Intertank
T07R9022A	1073.8	180.0	Island 23	Intertank
T07R9025A	1489.0	264.4	Island 29	LH2 Barrel
T07R9026A	1489.0	172.5	Island 28	LH2 Barrel
T07R9027A	2017.0	5.6	Island 33	LH2 Barrel
T07R9028A	2057.0	5.6	Island 35	LH2 Barrel
T07R9029A	2002.5	168.7	Island 32	LH2 Barrel
T07R9030A	2038.97	356.3	Island 34	LH2 Barrel
T07R9031A	2057.0	276.0	Island 36	LH2 Barrel
T07R9032A	2057.0	340.6	Island 37	LH2 Barrel
T07R9038A	996.0	23.0	Ind. Gage	L02 Fdln Fairing (top)
T07R9039A	1129.9	356.0	Ind. Gage	ET/ORB Fwd LH Strut
T07R9041A	959.2	270.0	Ind. Gage	Bolt Catcher
T07R9042A	2002.0	29.0	Ind. Gage	RH Thrust Strut
T07R9045A	2058.0	10.0	Ind. Gage	Aft Diag. Strut
T07R9046A	2100.0	45.0	Ind. Gage	LH Vert Strut Cable Tray
T07R9047A	2035.0	26.0	Ind. Gage	Fwd. L02 Fdln/X-Beam Cable Tray

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Table 2.2 STS-2 ET INTERFERENCE FACTORS FROM THE IH-97A WIND TUNNEL DATA BASE

FLIGHT GAGE NO.	IH97A GAGE NO.	HI/HU @ MACH NUMBER						
		2.25	2.50	2.75	3.00	3.25	3.50	3.75
9001	5029	1.180	1.122	1.048	1.646	1.836	1.952	2.235
9004	5031	0.991	1.000	0.997	0.988	0.925	0.916	0.911
9005	5030	0.947	0.938	0.914	0.984	0.928	0.930	0.897
9007	5033	0.957	0.888	0.858	0.869	0.774	0.795	0.835
9008	5032	1.120	1.156	1.127	1.170	1.135	1.124	1.026
9010	5034	0.459	0.424	0.367	0.351	0.343	0.293	0.316
9011	5042	1.603	1.619	1.798	1.708	1.583	1.623	1.617
9013	5041				4.290	2.996	3.236	4.471
9014	5038	3.474	3.223	3.367	3.724	3.992	5.099	5.874
9015	5258	6.505	8.366		9.567	9.592	10.803	12.326
9016	5036	5.242	5.412	6.619	5.167	4.839	5.191	5.185
9017	5035	0.620	0.642	0.635	0.760	0.709	0.720	0.742
9018	5039	3.424	4.219	4.053	3.809	2.587	2.544	3.687
9019	5040	3.095	3.533	3.277	2.833	2.177	1.797	2.546
9021	5043	0.112	0.277	0.397	0.513	1.339	1.379	1.404
9022	5044	1.320	1.078	0.624	0.688	0.650	0.642	0.719
9025	5046	1.045	1.056	1.395	1.487	1.526	0.961	0.963
9026	5045	0.645	0.707	0.725	0.941	1.000	1.088	0.759
9027	5048	1.298	1.806	2.440	2.134	2.237	2.109	1.426
9028	5050	1.080	1.439	1.842	2.153	2.729	2.646	2.276
9029	5047	0.545	0.392	0.454	0.462	0.464	0.367	0.249
9030	5049	3.084	3.729	1.510	1.428	3.341	2.646	3.507
9031	5051	2.615	3.656	4.091	2.888	1.854	1.882	6.903
9032	5052	2.440	2.961	2.600	2.255	2.345	2.255	3.076

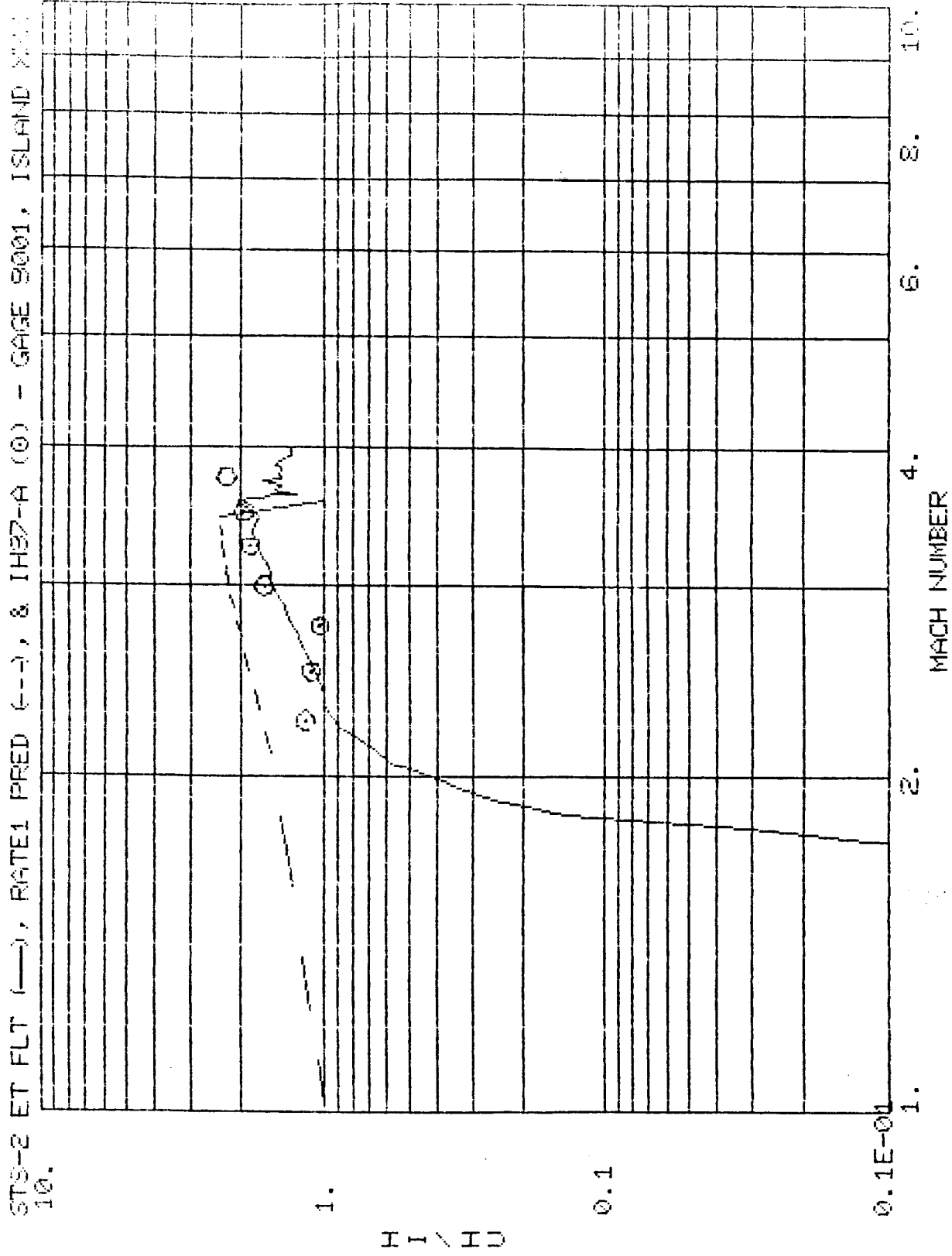


Fig. 2.1

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9004, ISLAND 2

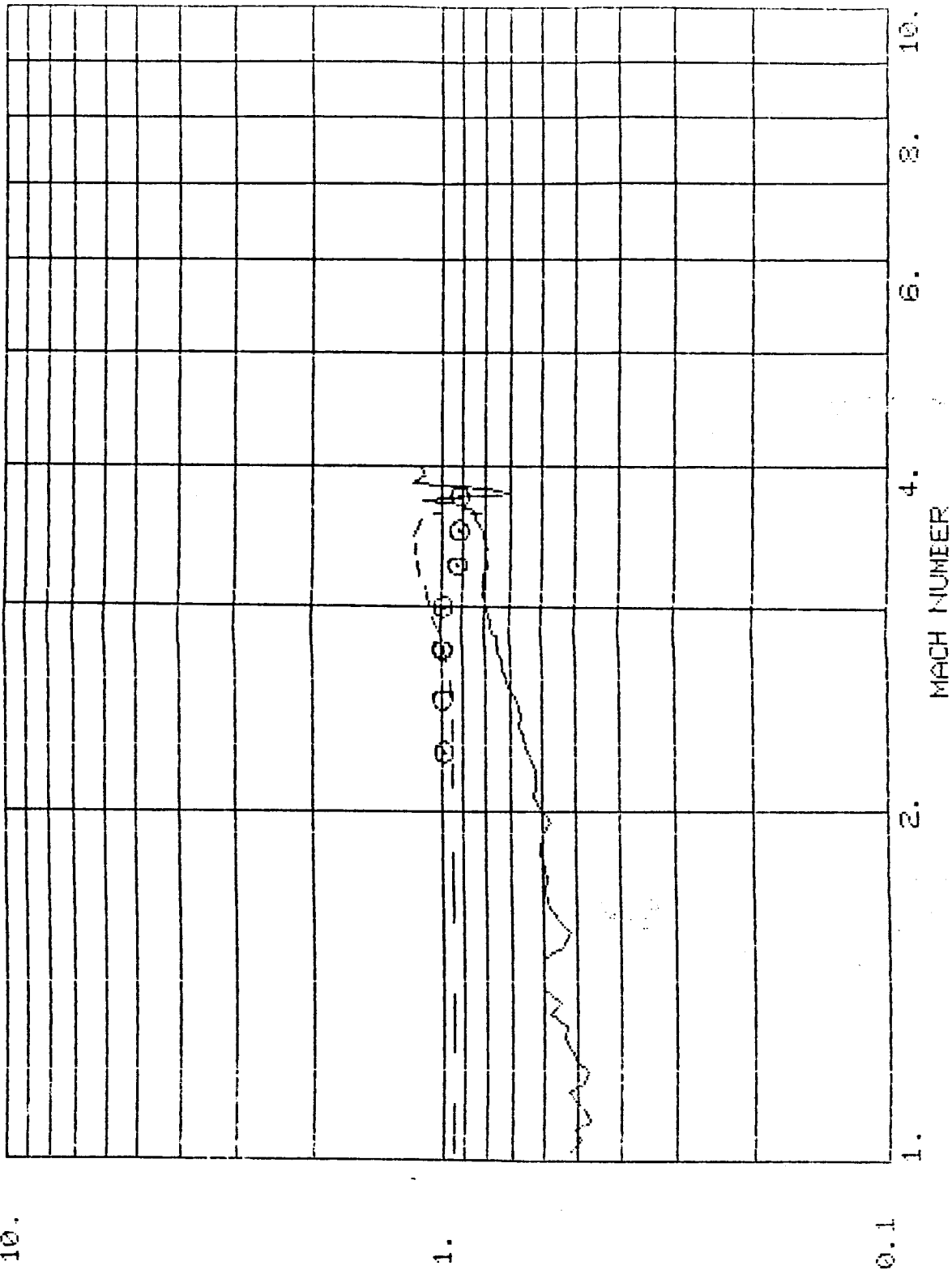


Fig. 2.2

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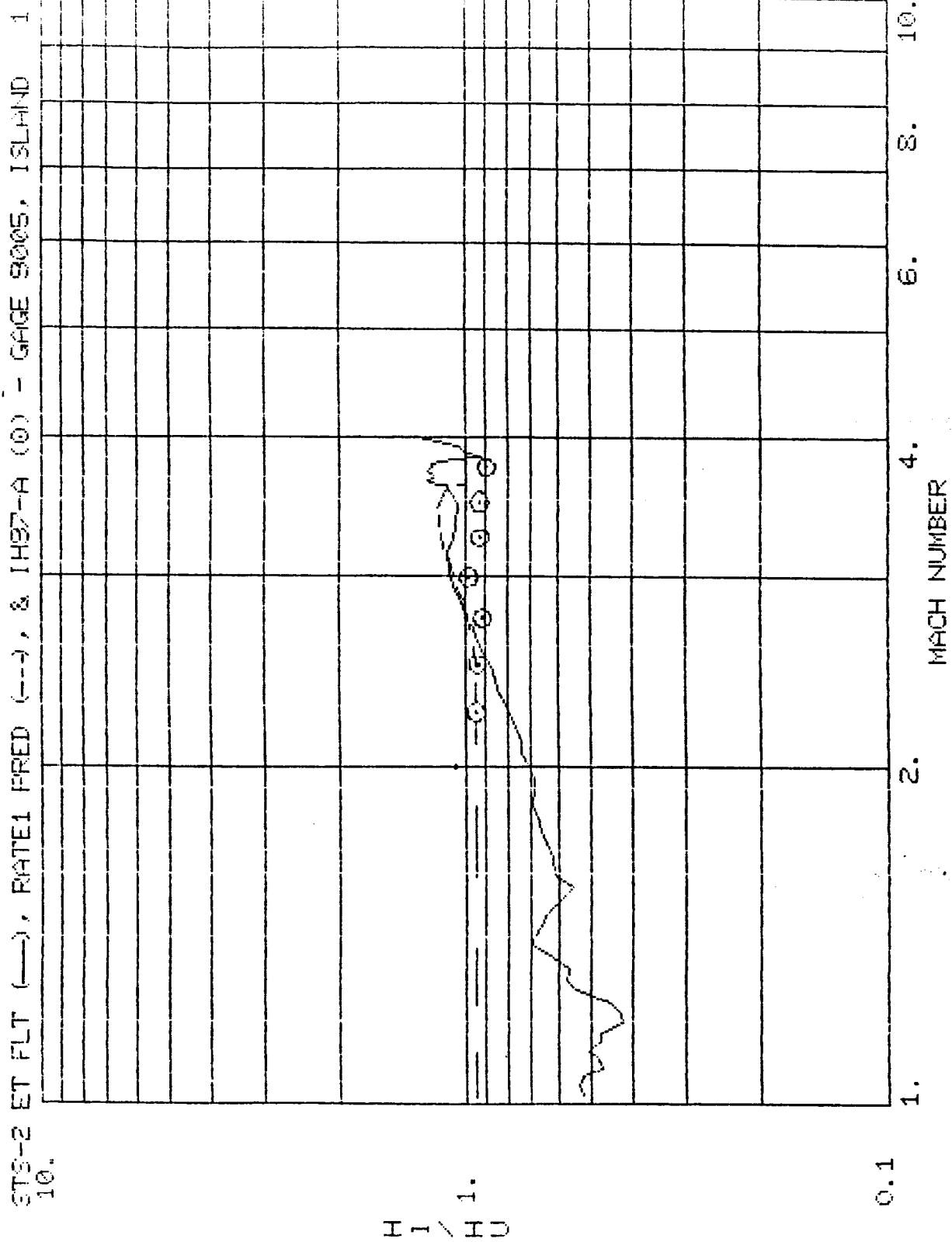


Fig. 2.3

STS-2 ET FLT (—), RATE1 PRED (---), & IH87-A (O) - GAGE 9007, ISLAND S

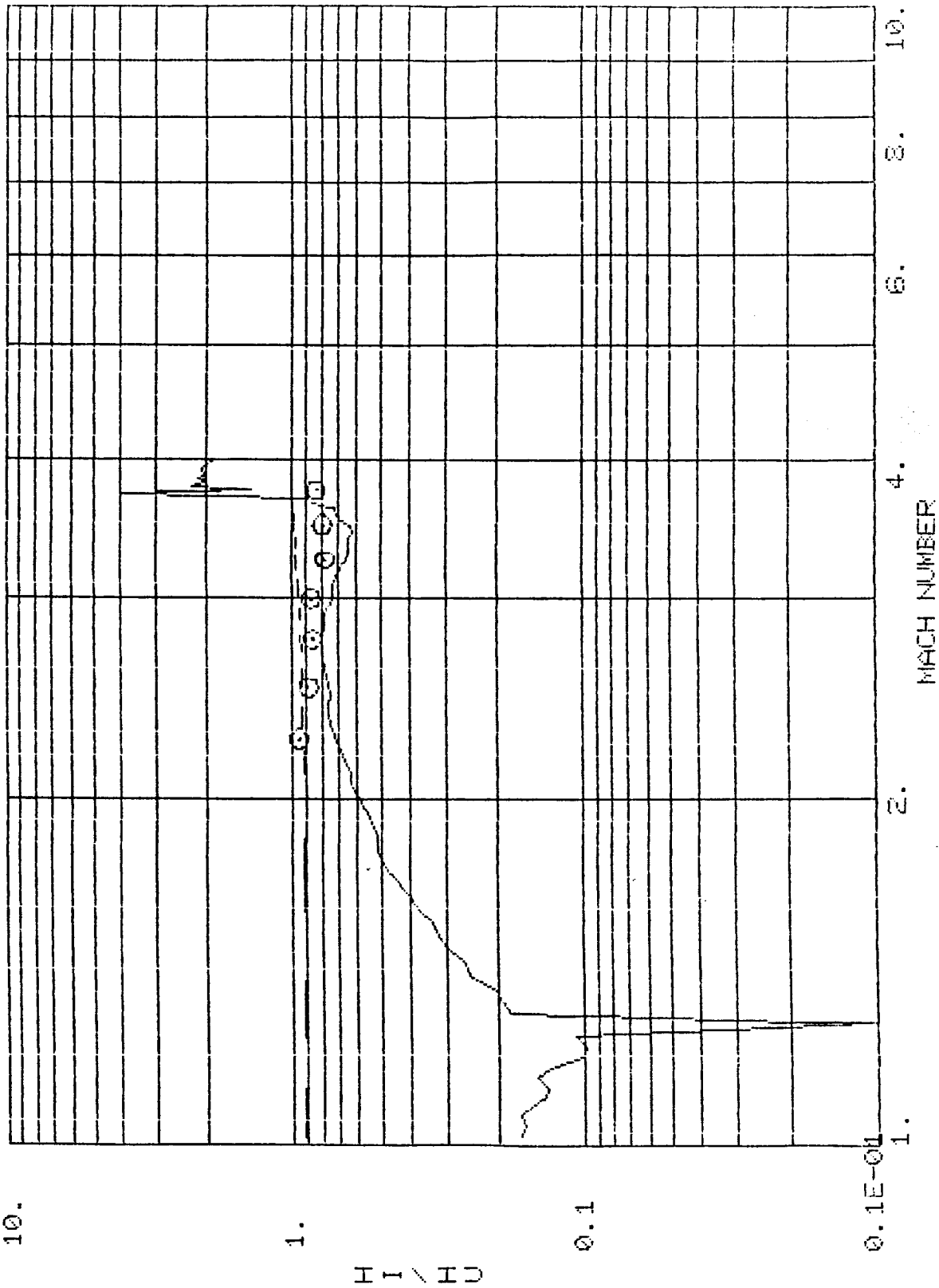


Fig. 2.4

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9008, ISLAND 5

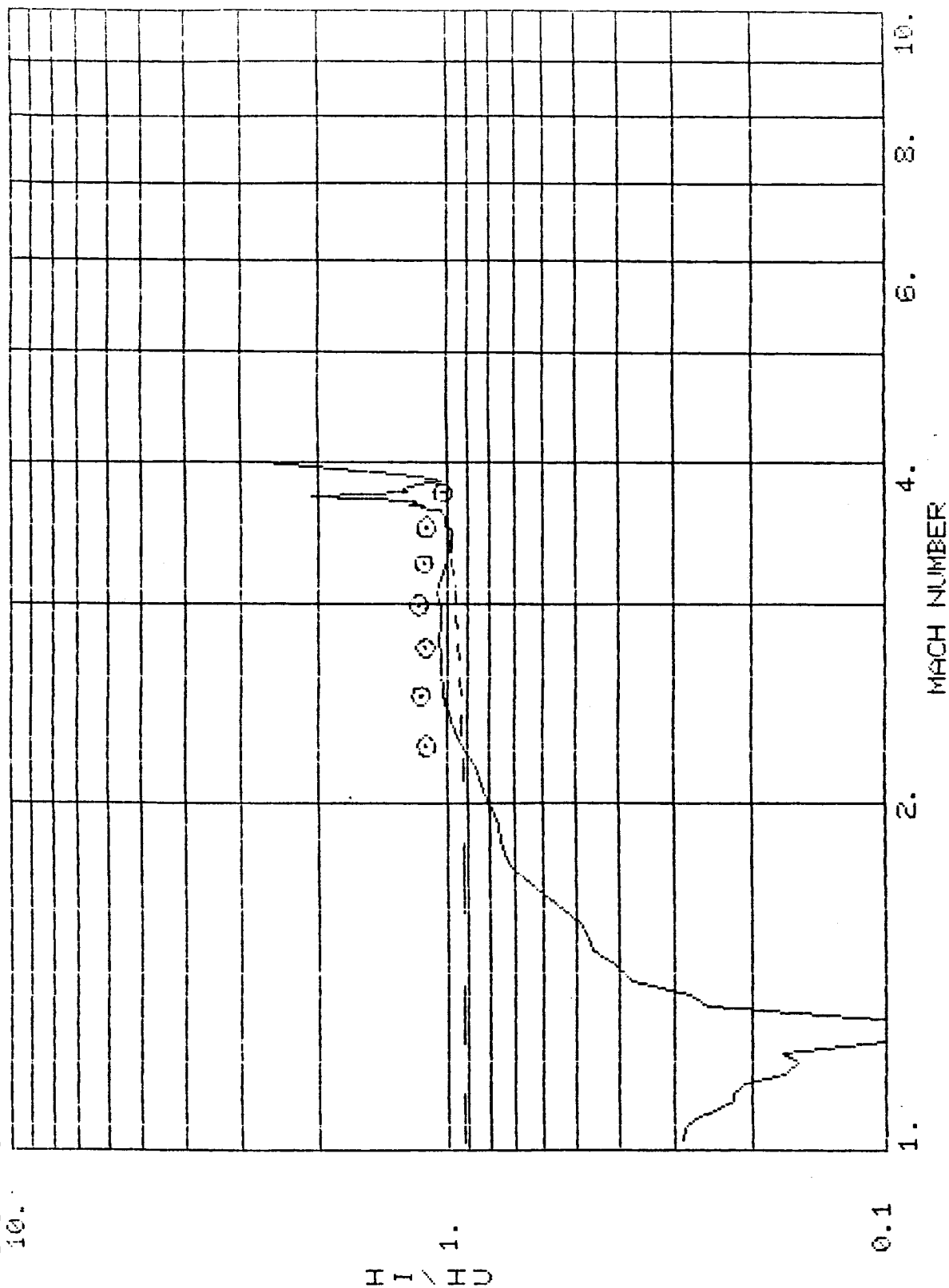


Fig. 2.5

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9010, ISLAND 8
100.

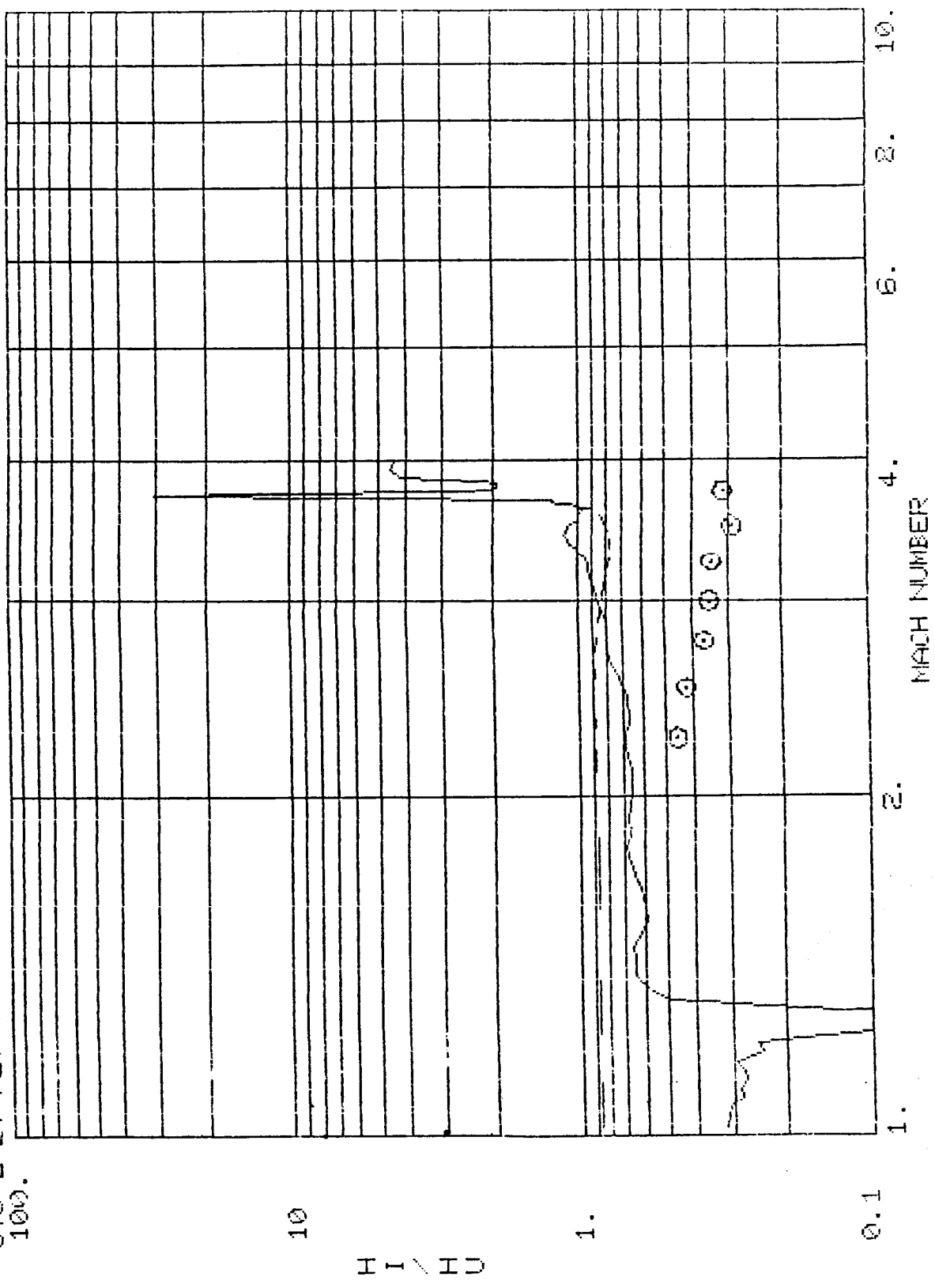


Fig. 2.6

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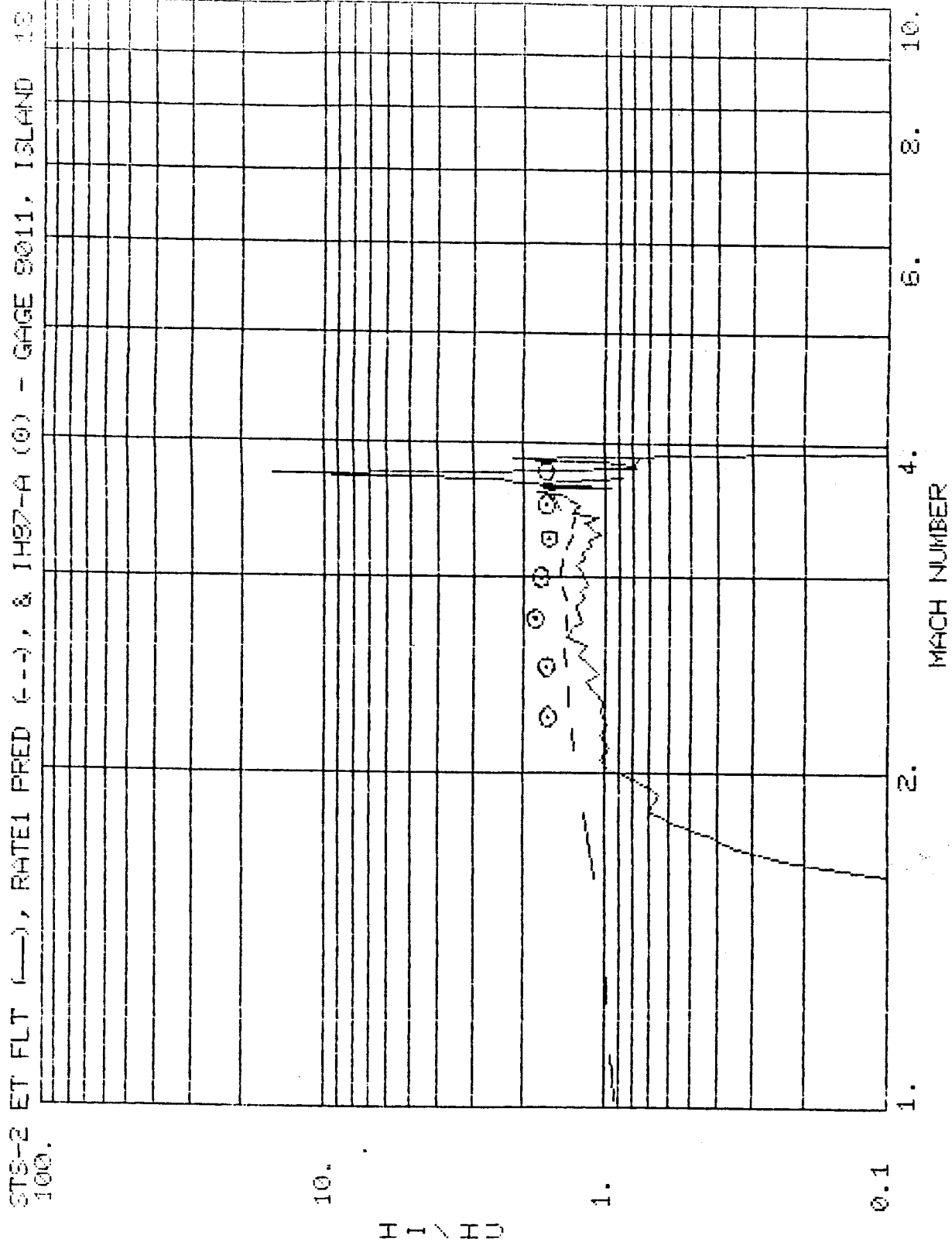


Fig. 2.7

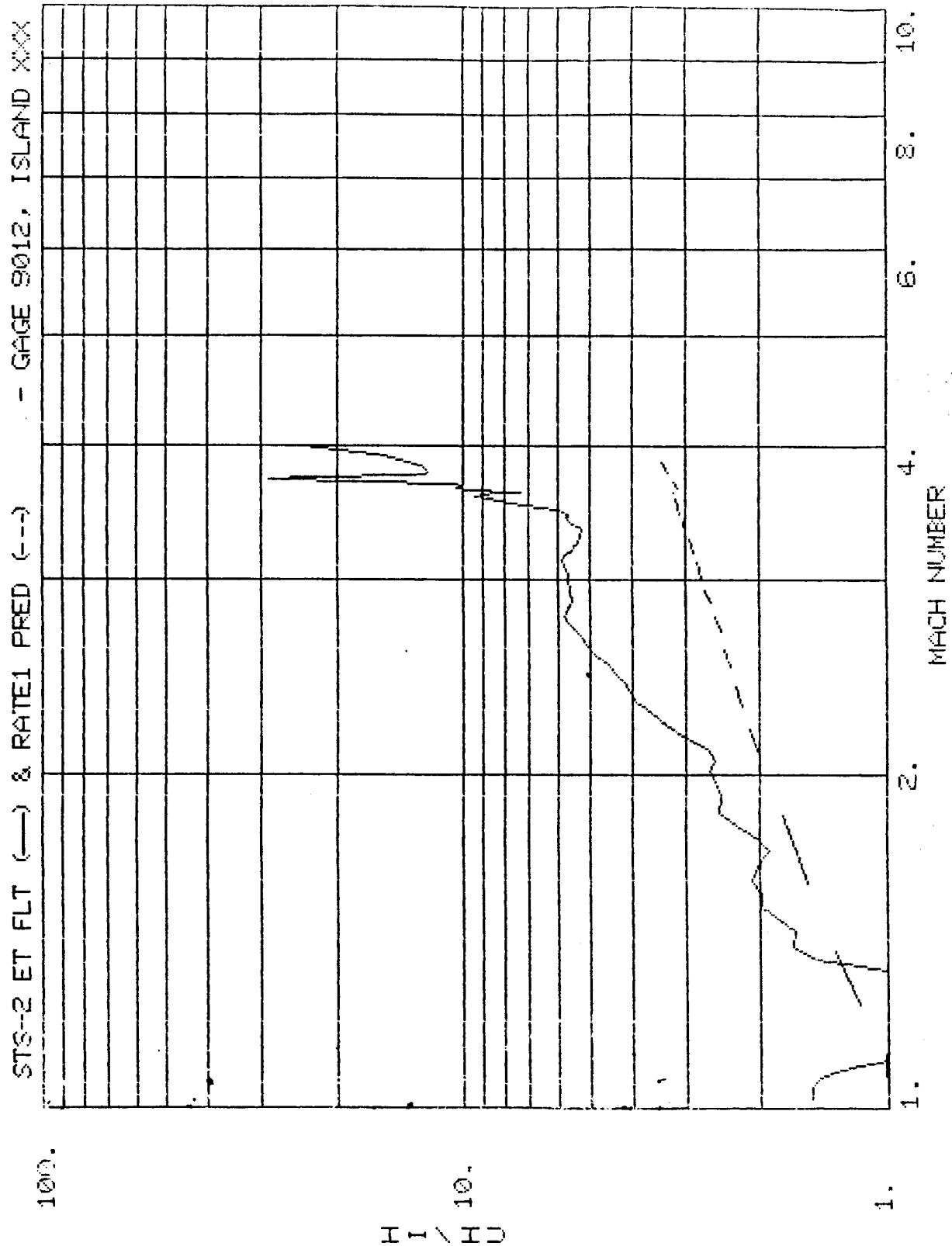


Fig. 2.8

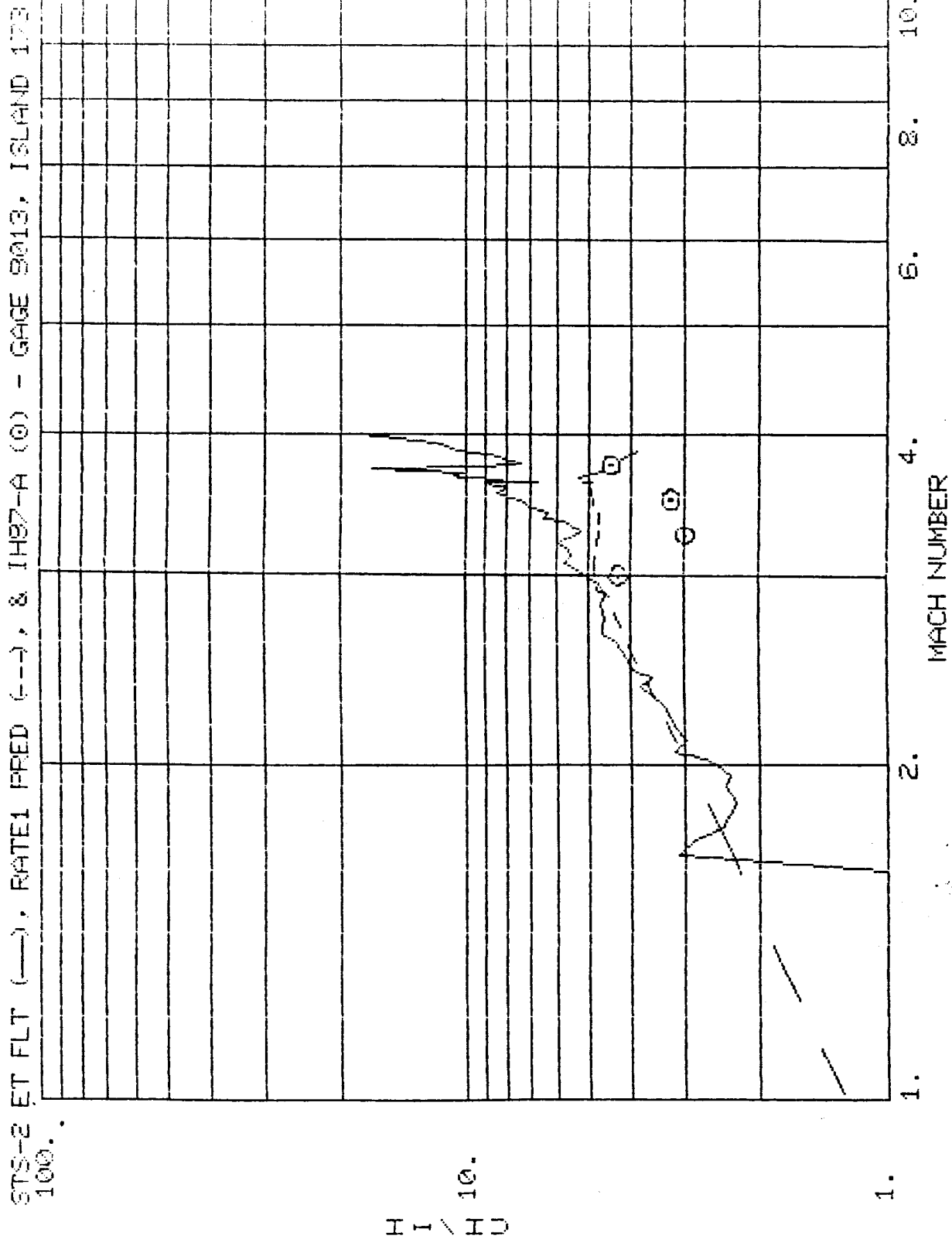


Fig. 2.9

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9014, ISLAND 16
100.

H_I / H_D
10.

1.

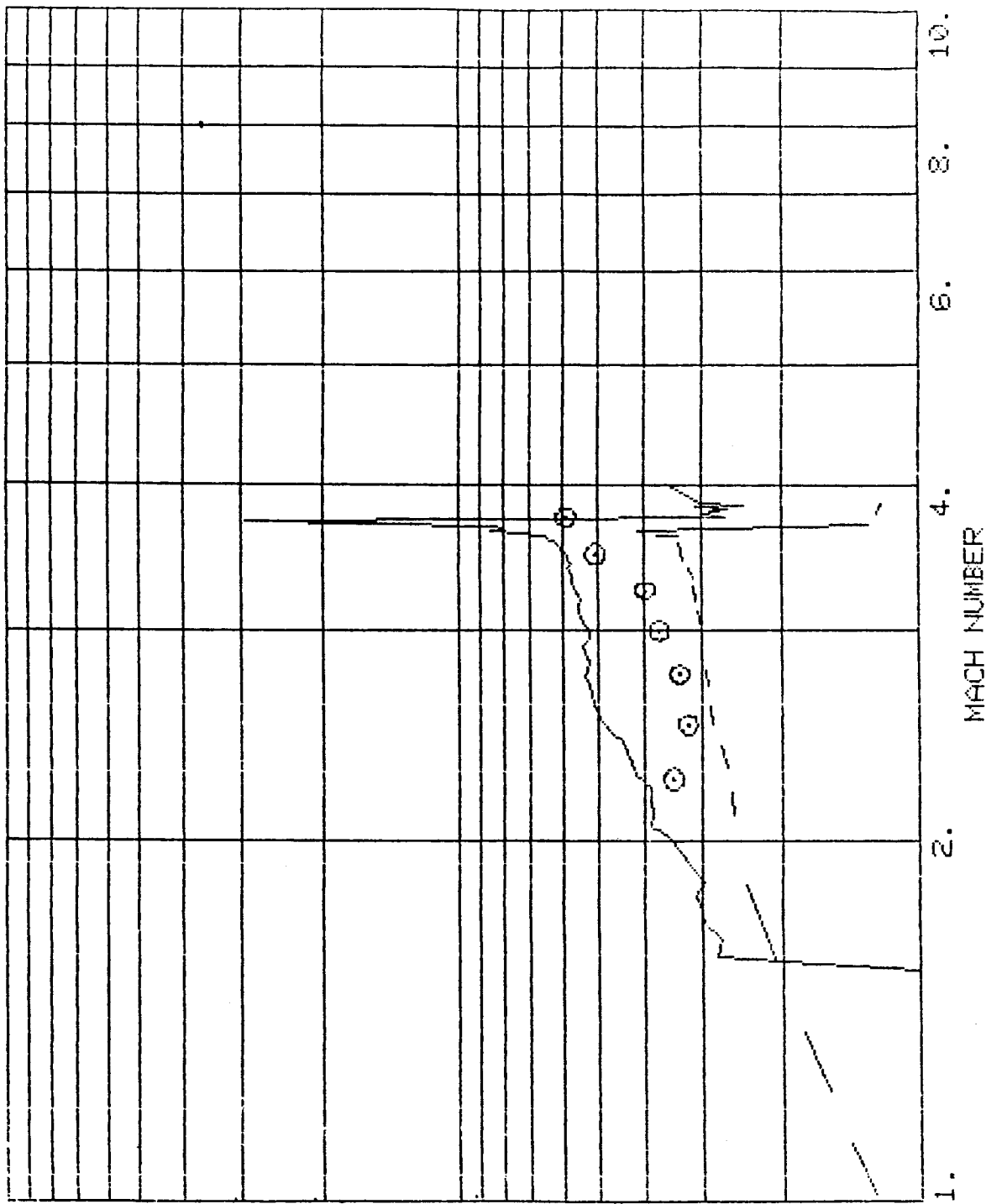


Fig. 2.10

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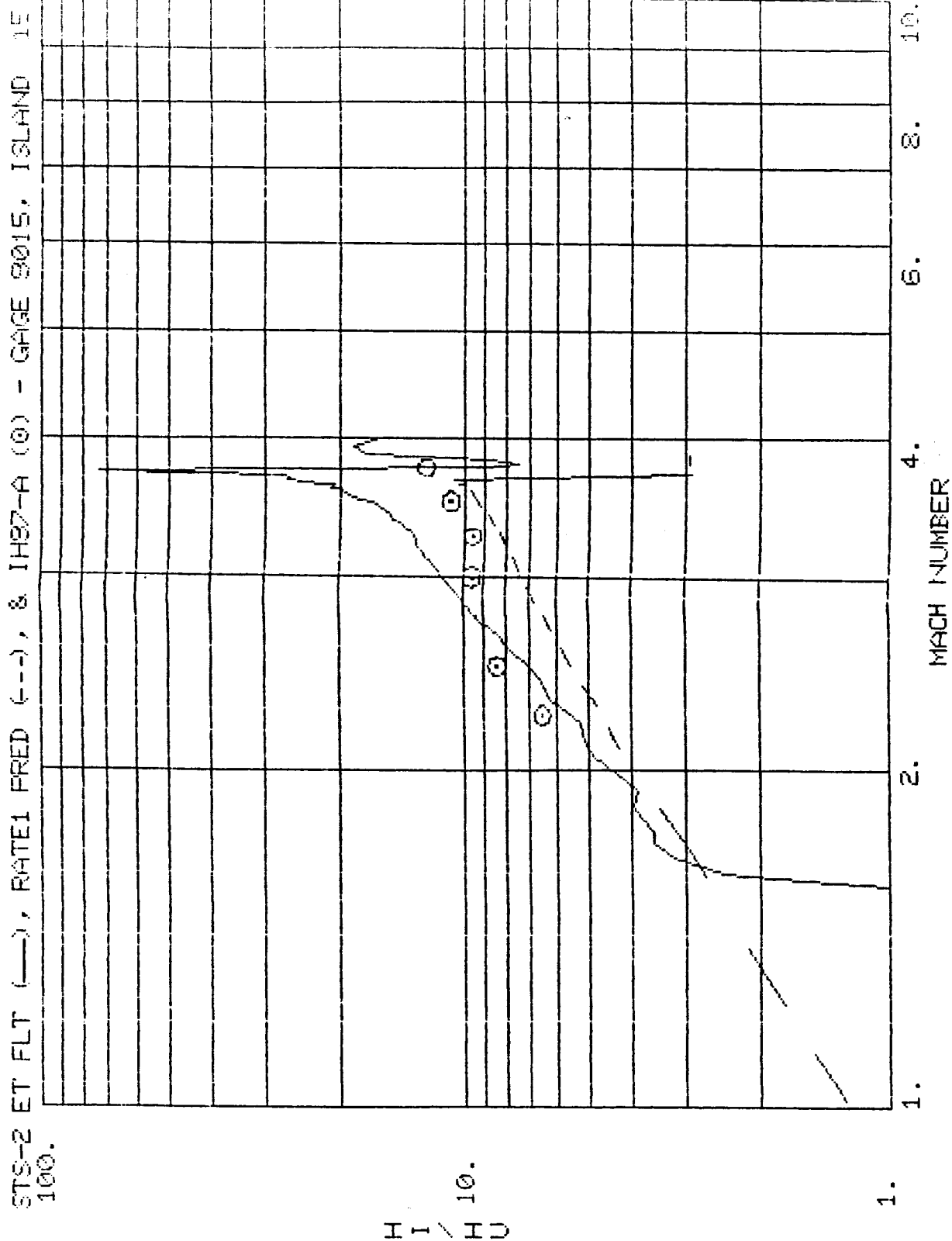


Fig. 2.11

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9016, ISLAND 14
100.

$\frac{H_I}{H_D} \times 10^3$

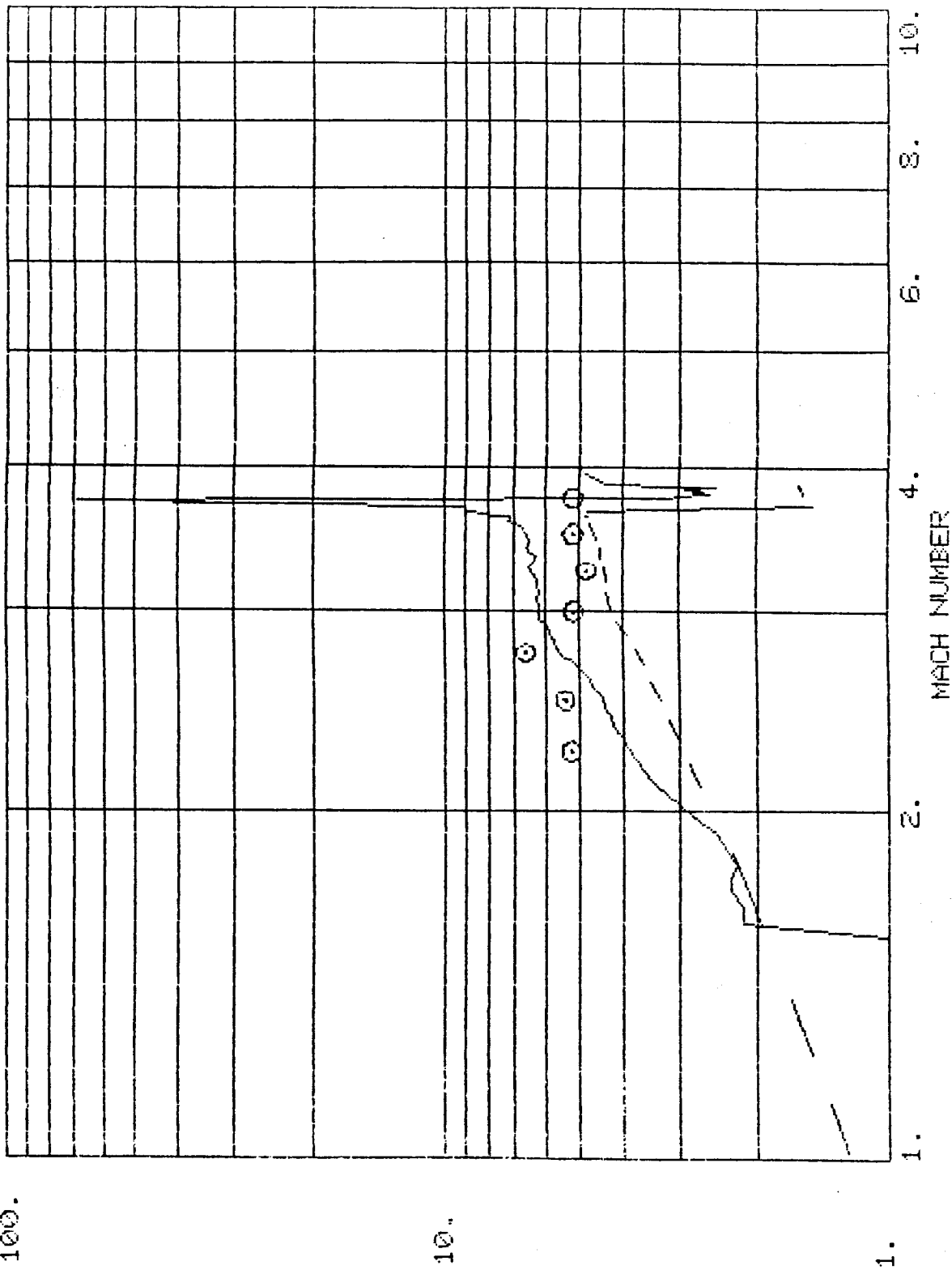


Fig. 2.12

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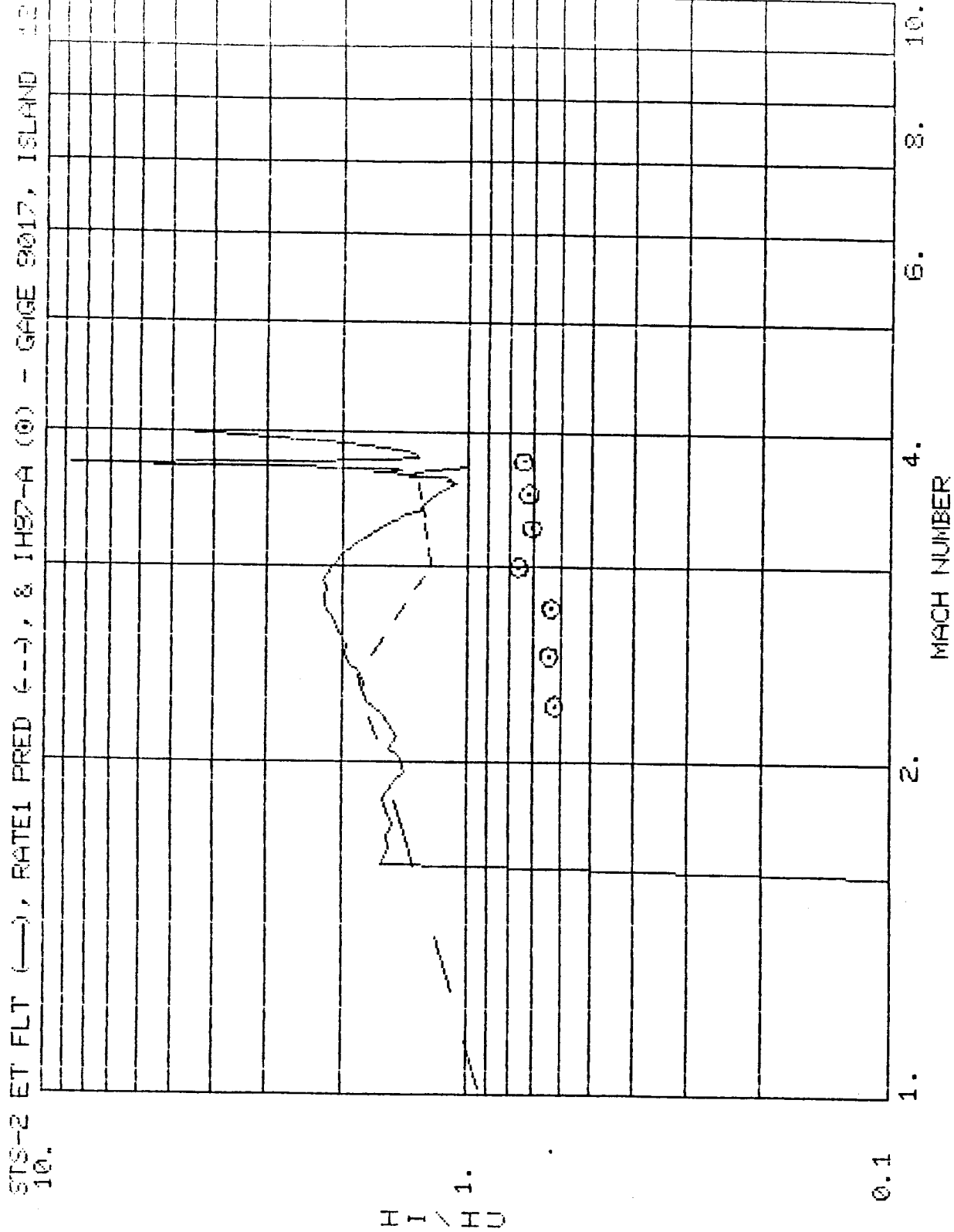


Fig. 2.13

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9013, ISLAND 172
100.

H_T / H_D 10.

1.

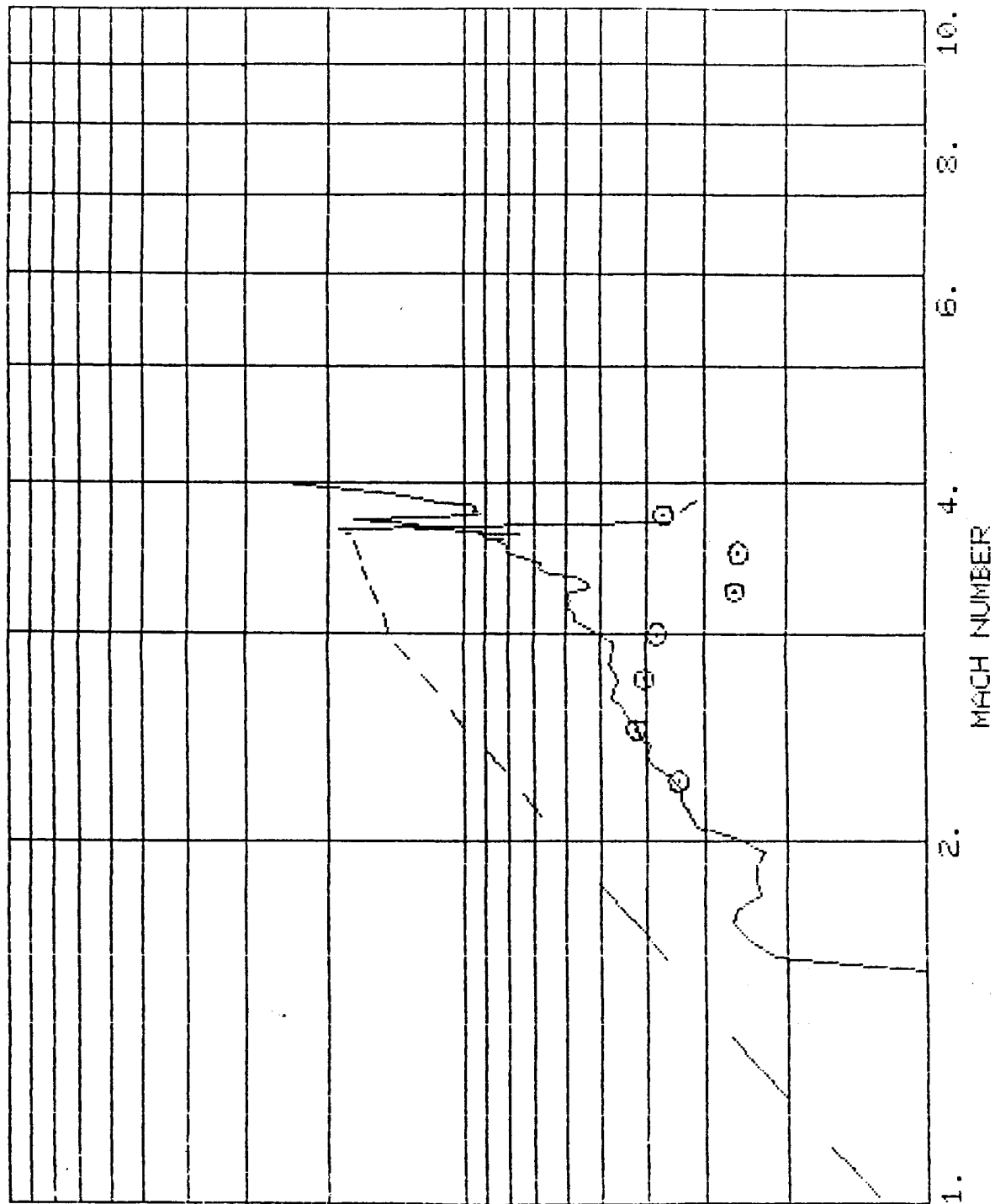


Fig. 2.14

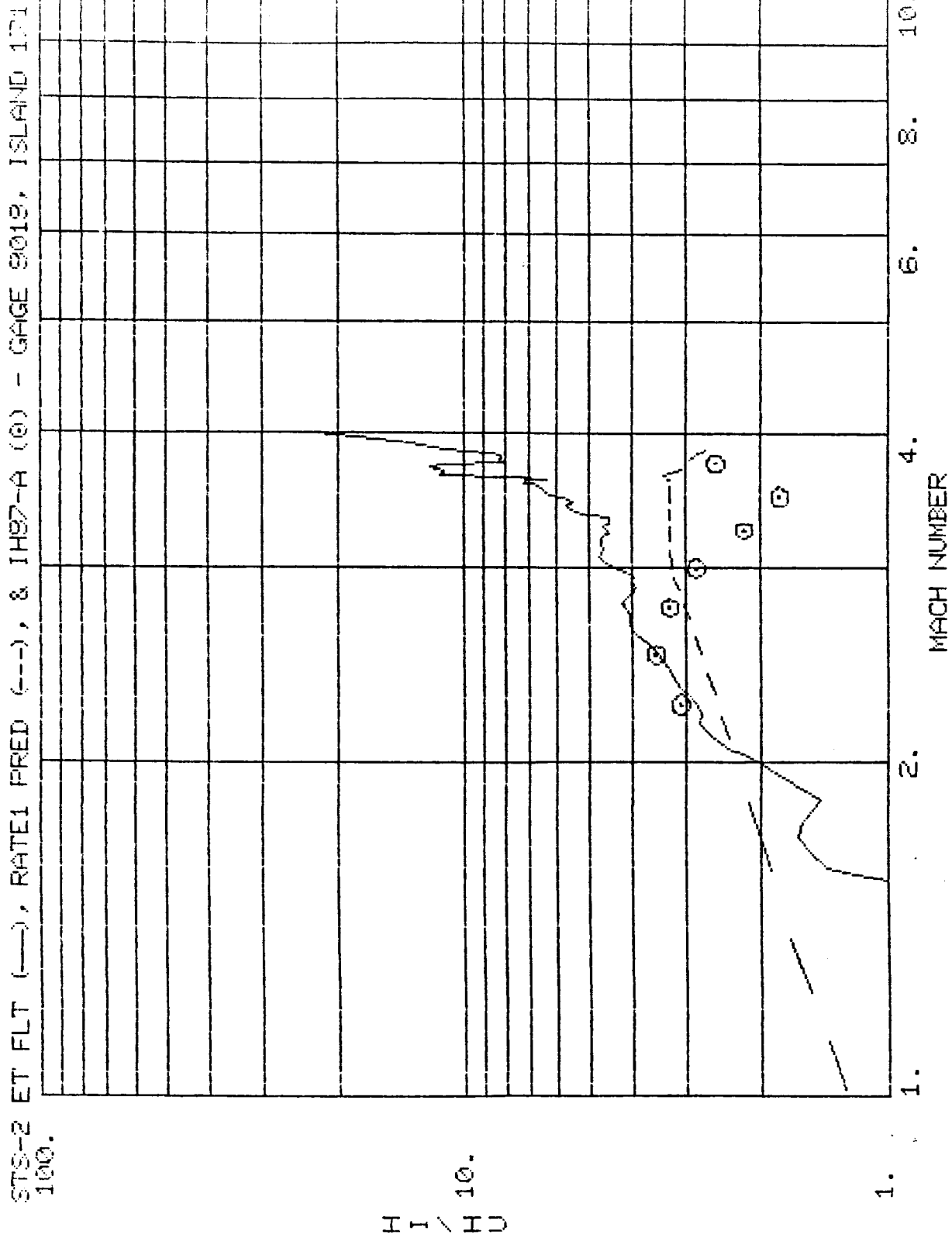


Fig. 2.15

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9021, ISLAND 20
100.

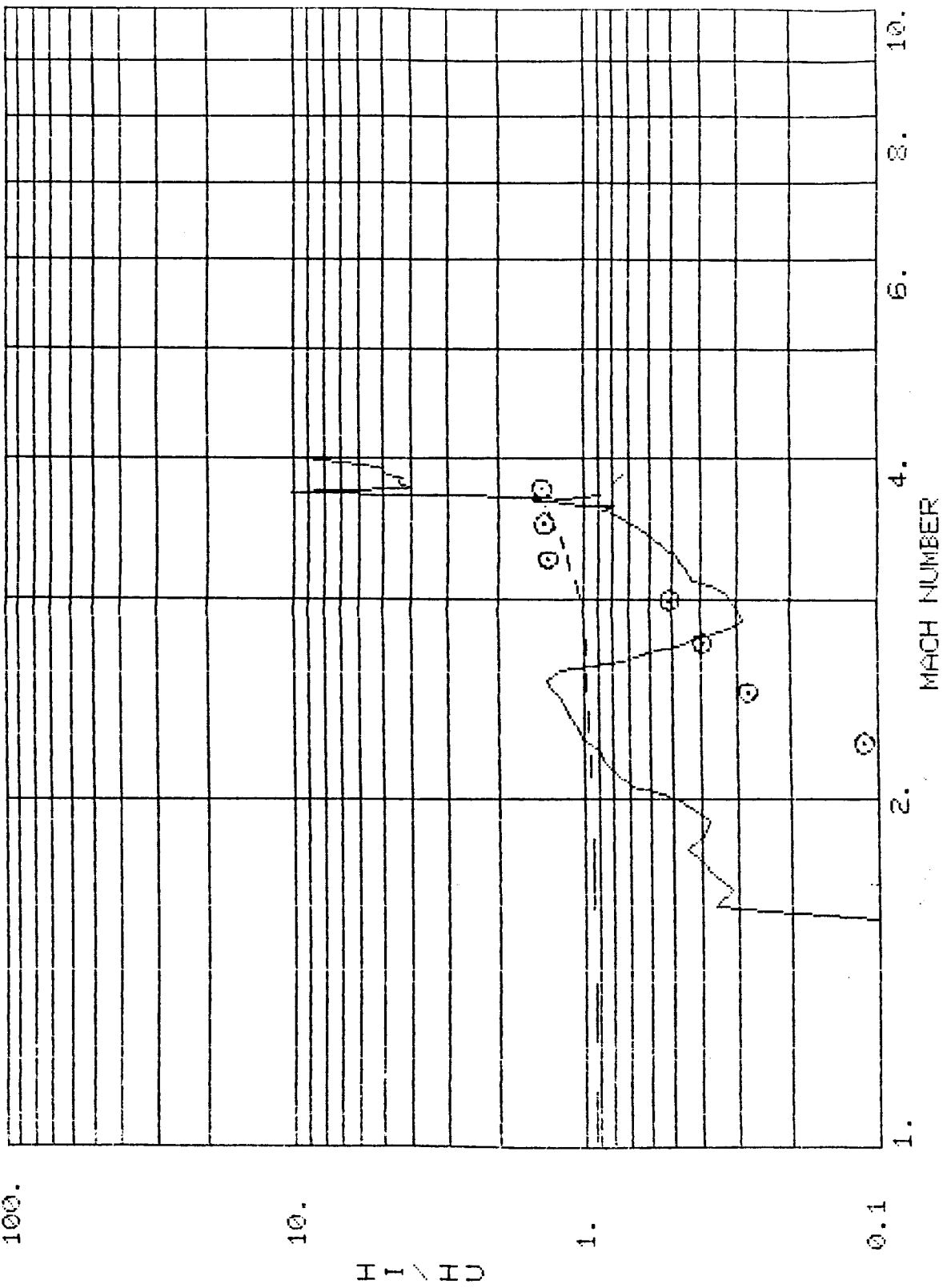


Fig. 2.16

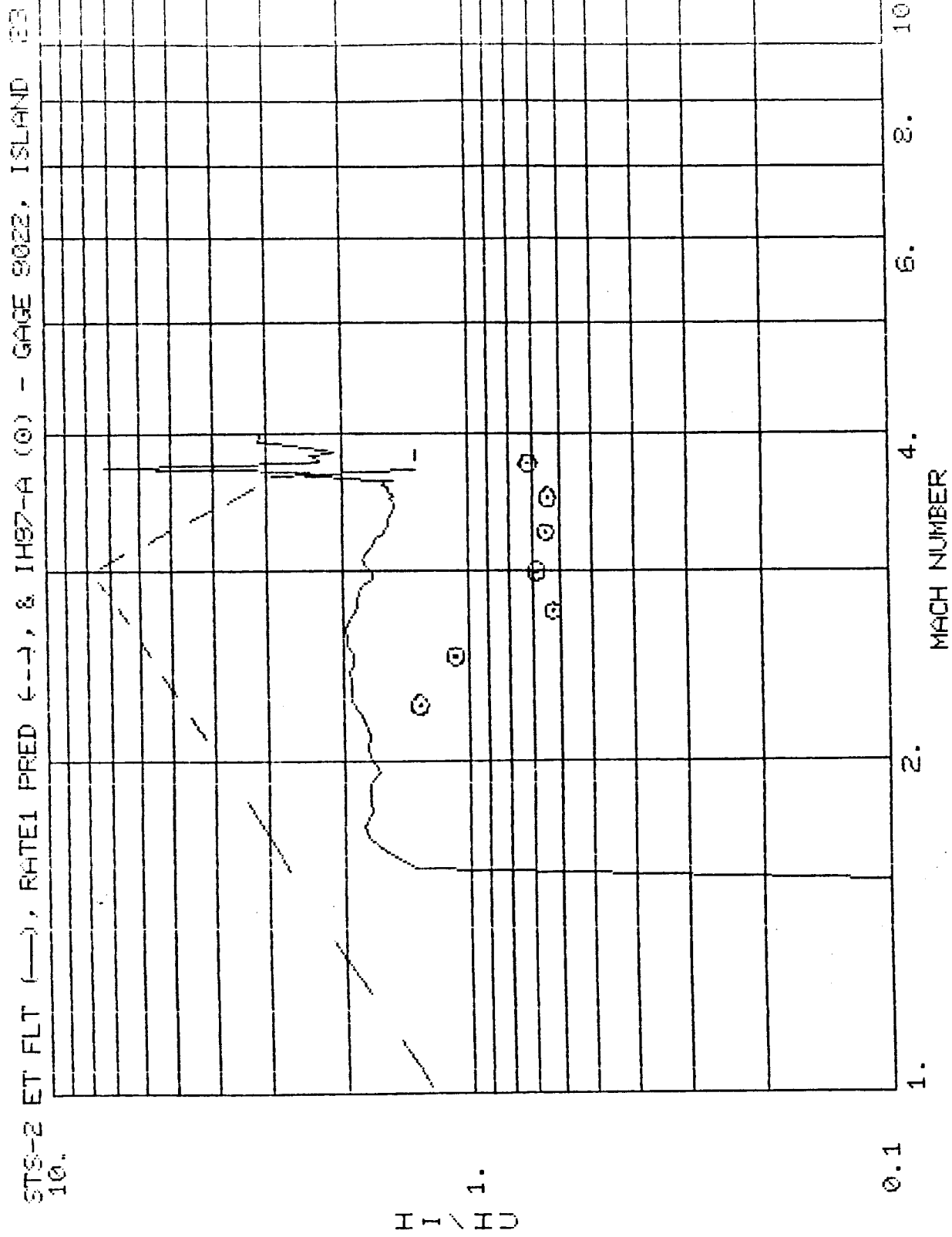


Fig. 2.17

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9025, ISLAND 28
10.

H I / H D 1.

0.1

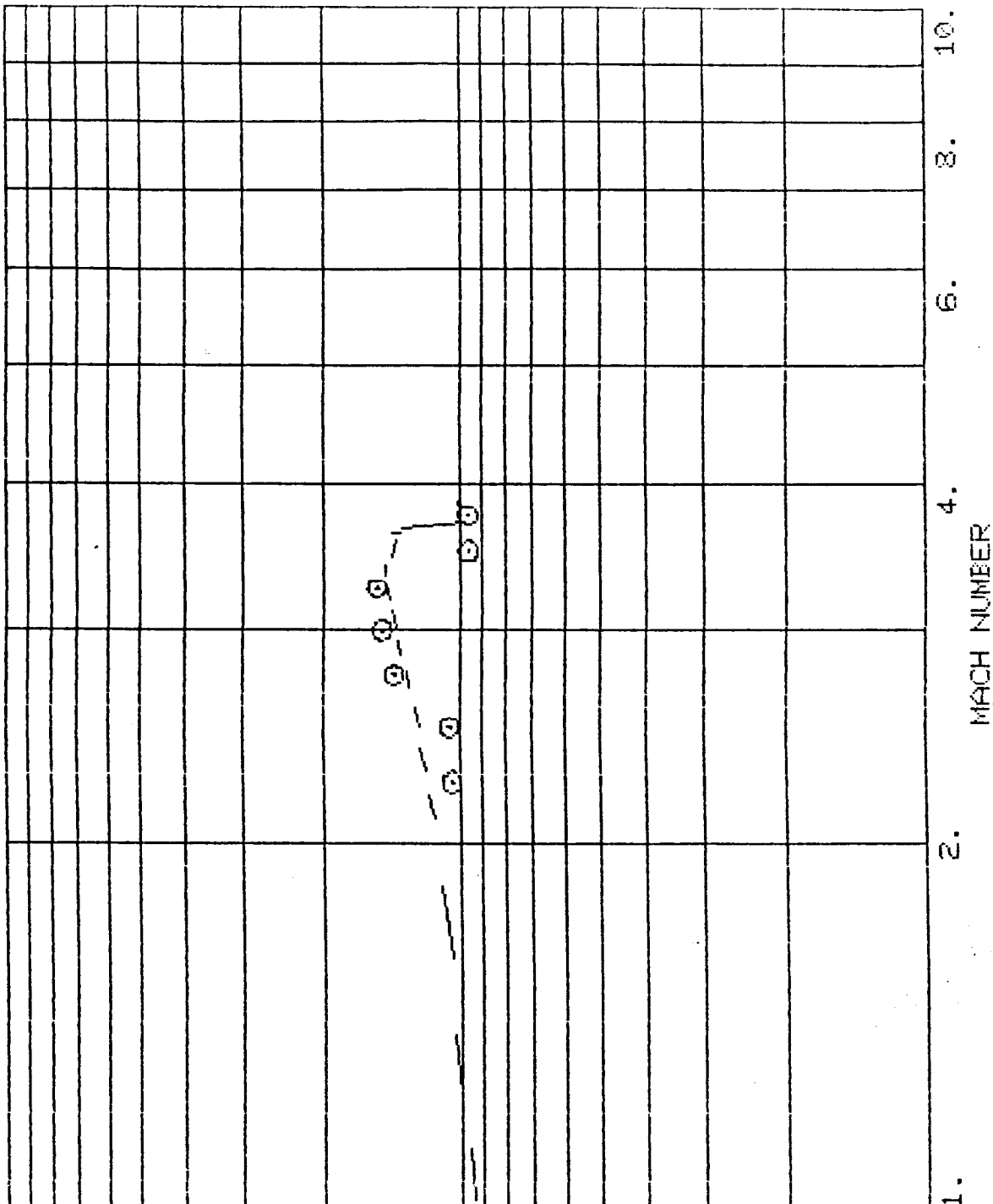


Fig. 2.18

NOTE: Bad Flight Data

STS-2 ET FLT (—), RATE1 PRED (- - -), & IH87-A (O) - GAGE 9026, ISLAND 23
10.

H I \ HU
1.

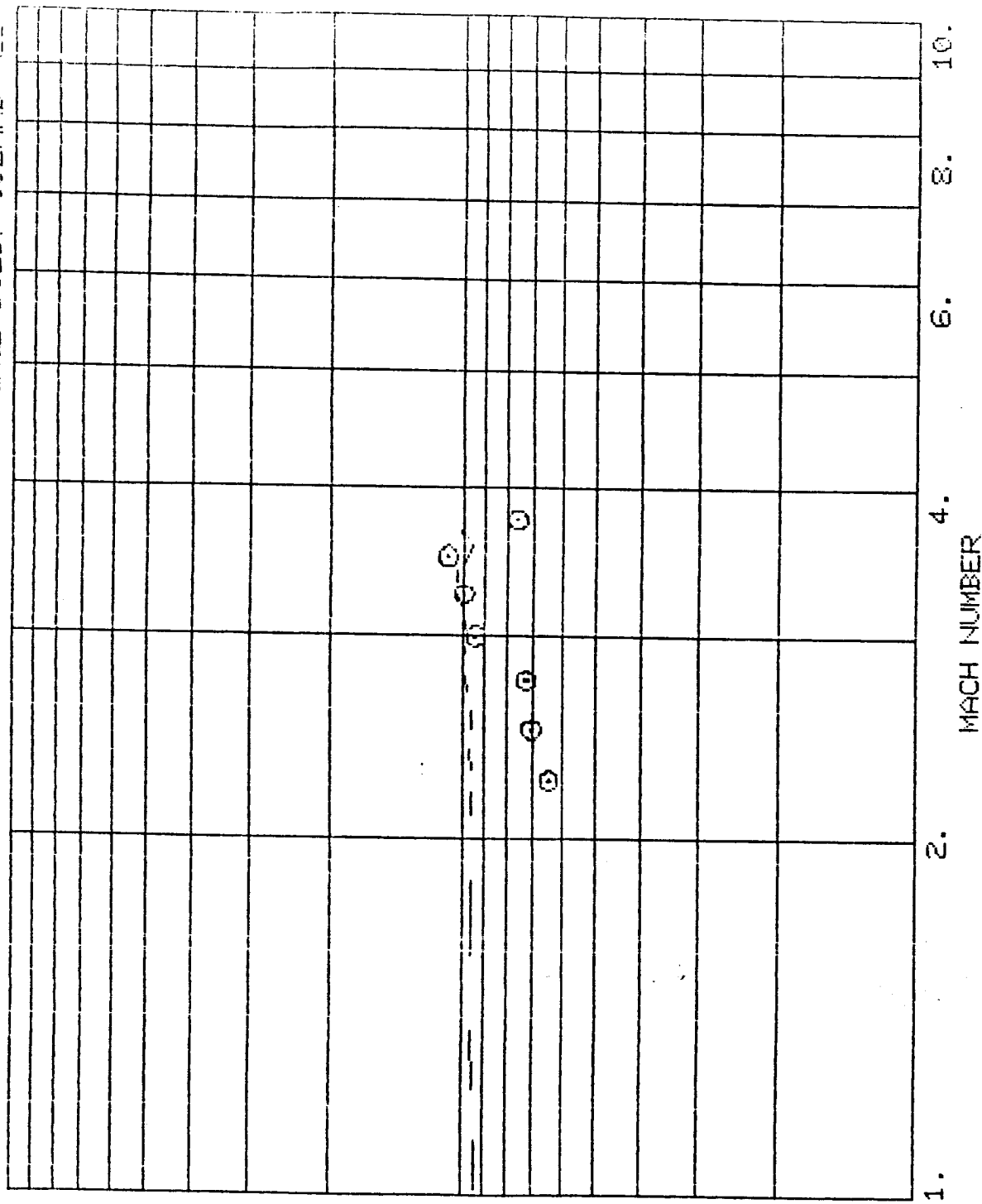


Fig. 2.19

NOTE: Bad Flight Data

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9027, ISLAND 33
100.

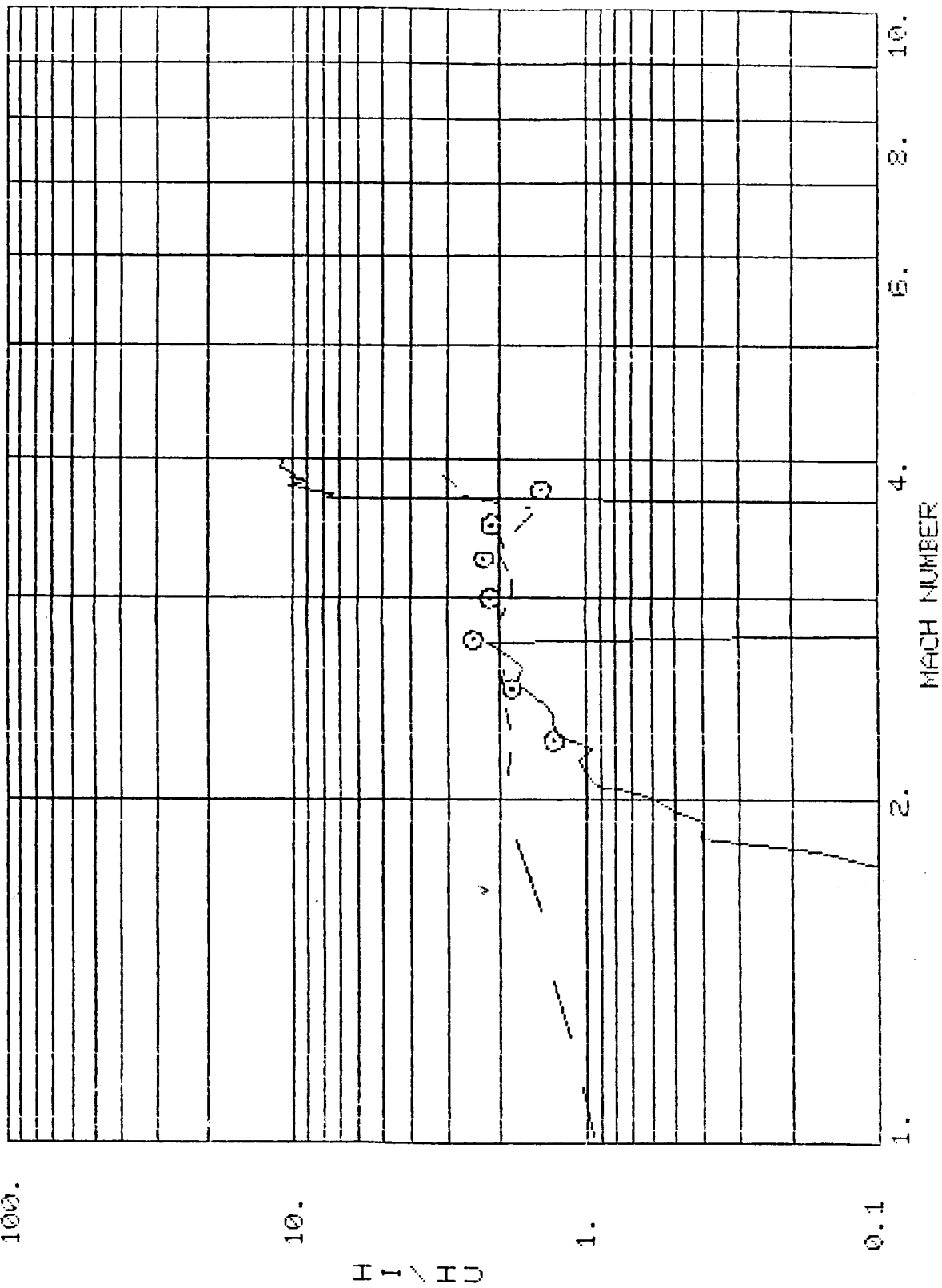


Fig. 2.20

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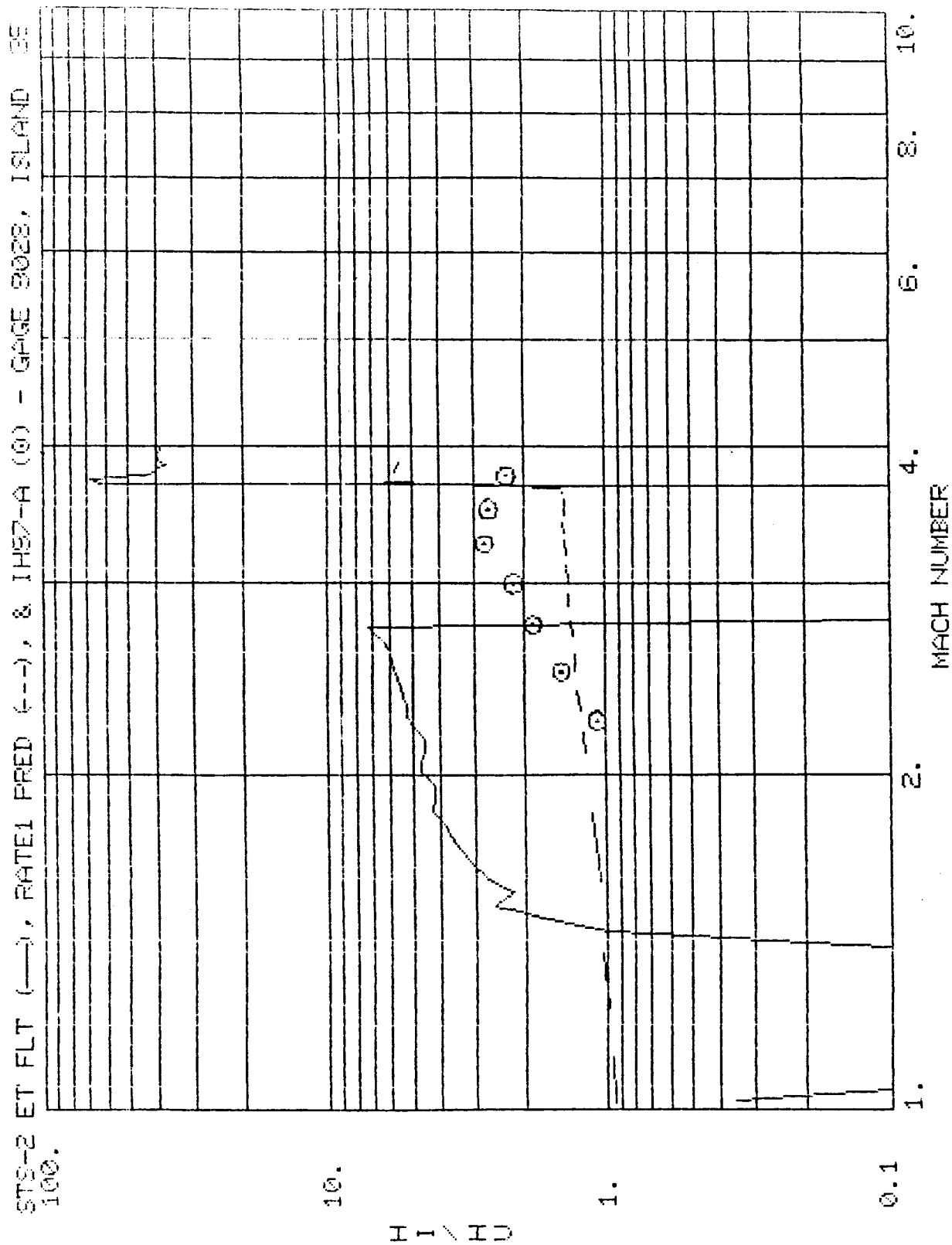


Fig. 2.21

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9029, ISLAND 32
10.

$\frac{H_I}{H_D}$ 1.

0.1

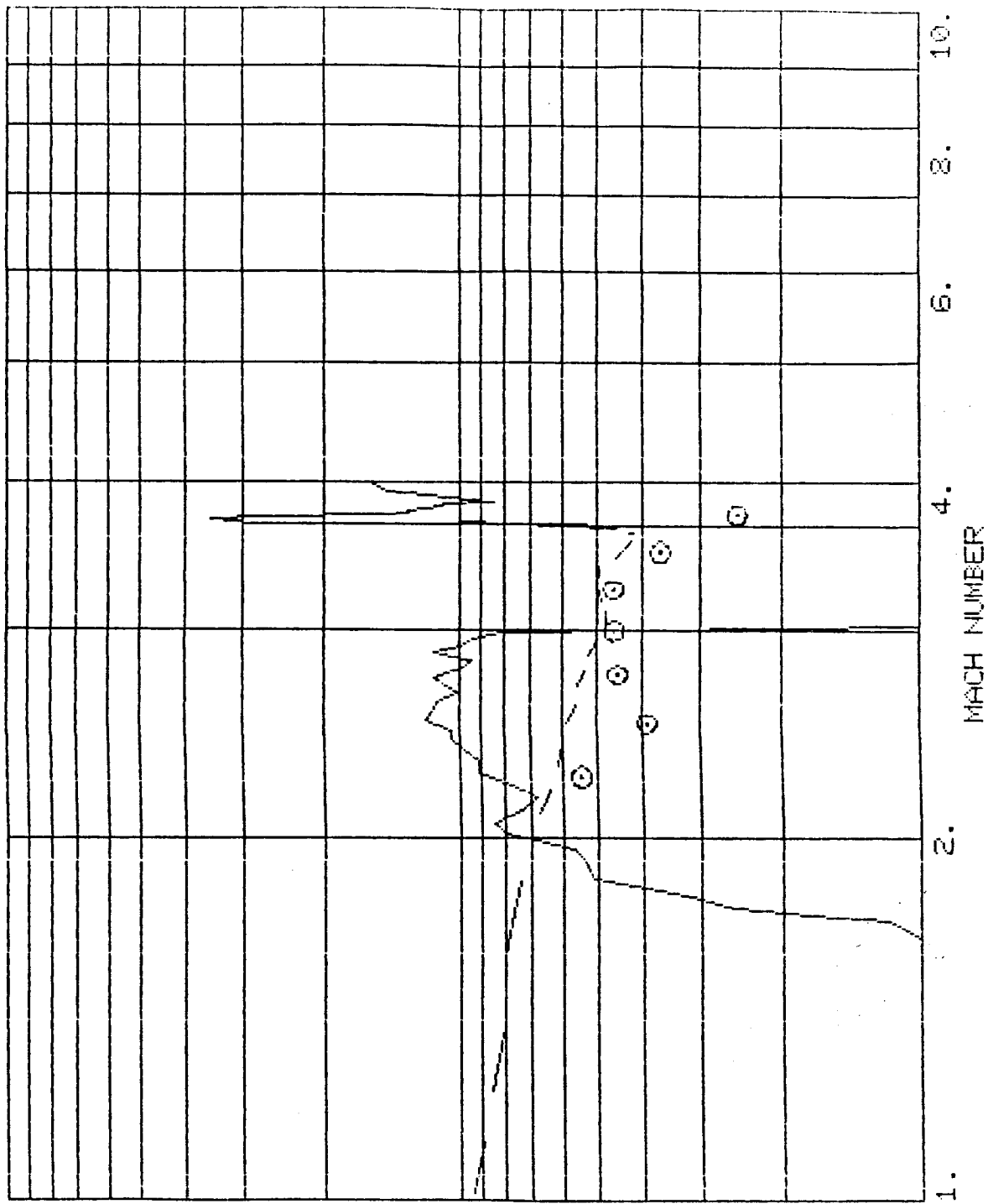


Fig. 2.22

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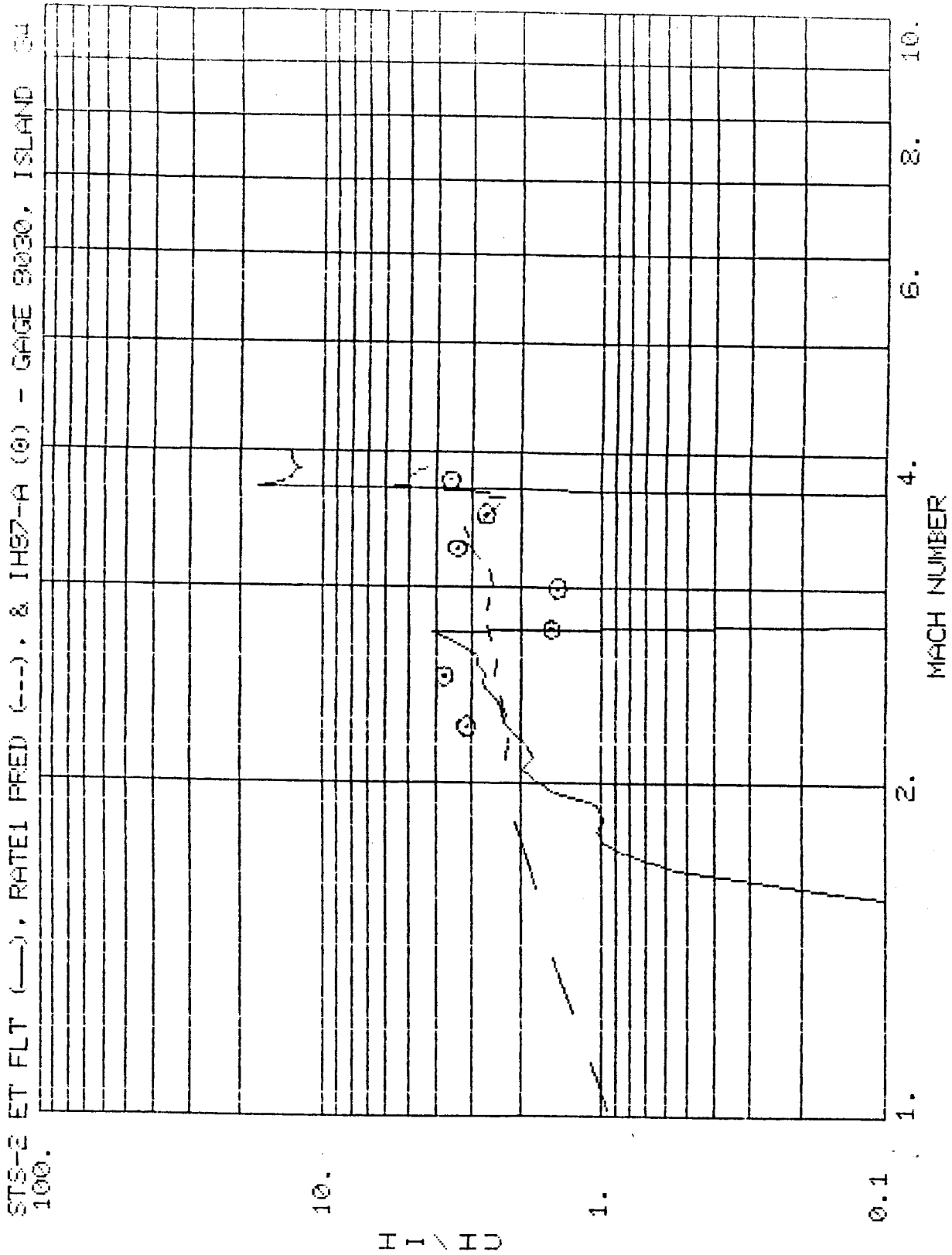


Fig. 2.23

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9031, ISLAND 36
10.

H I \ HD
1.

0.1

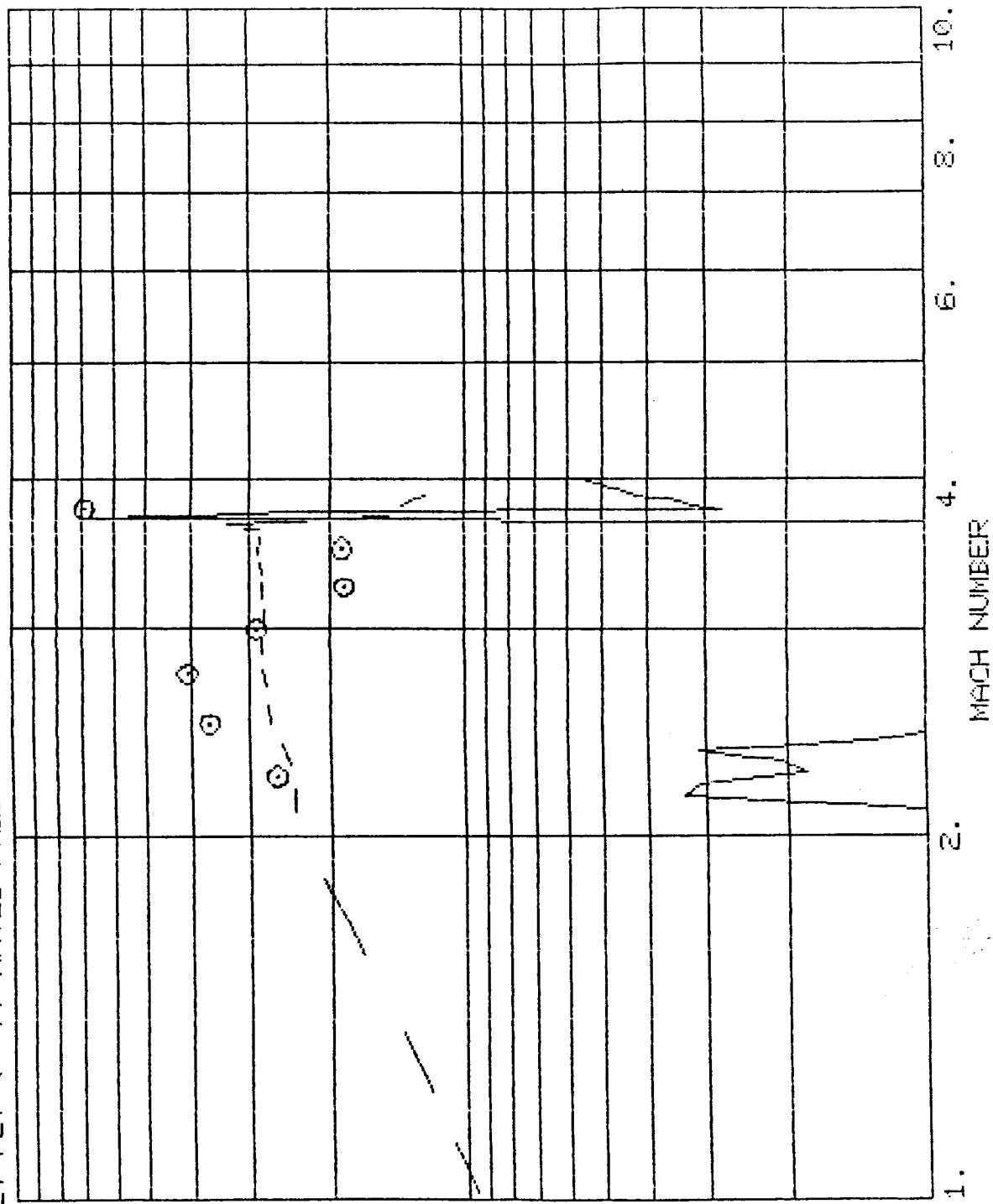


Fig. 2.24

STS-2 ET FLT (—), RATE1 PRED (---), & IH87-A (O) - GAGE 9032, ISLAND 37
100.

10.

H_I / H_D

1.

0.1

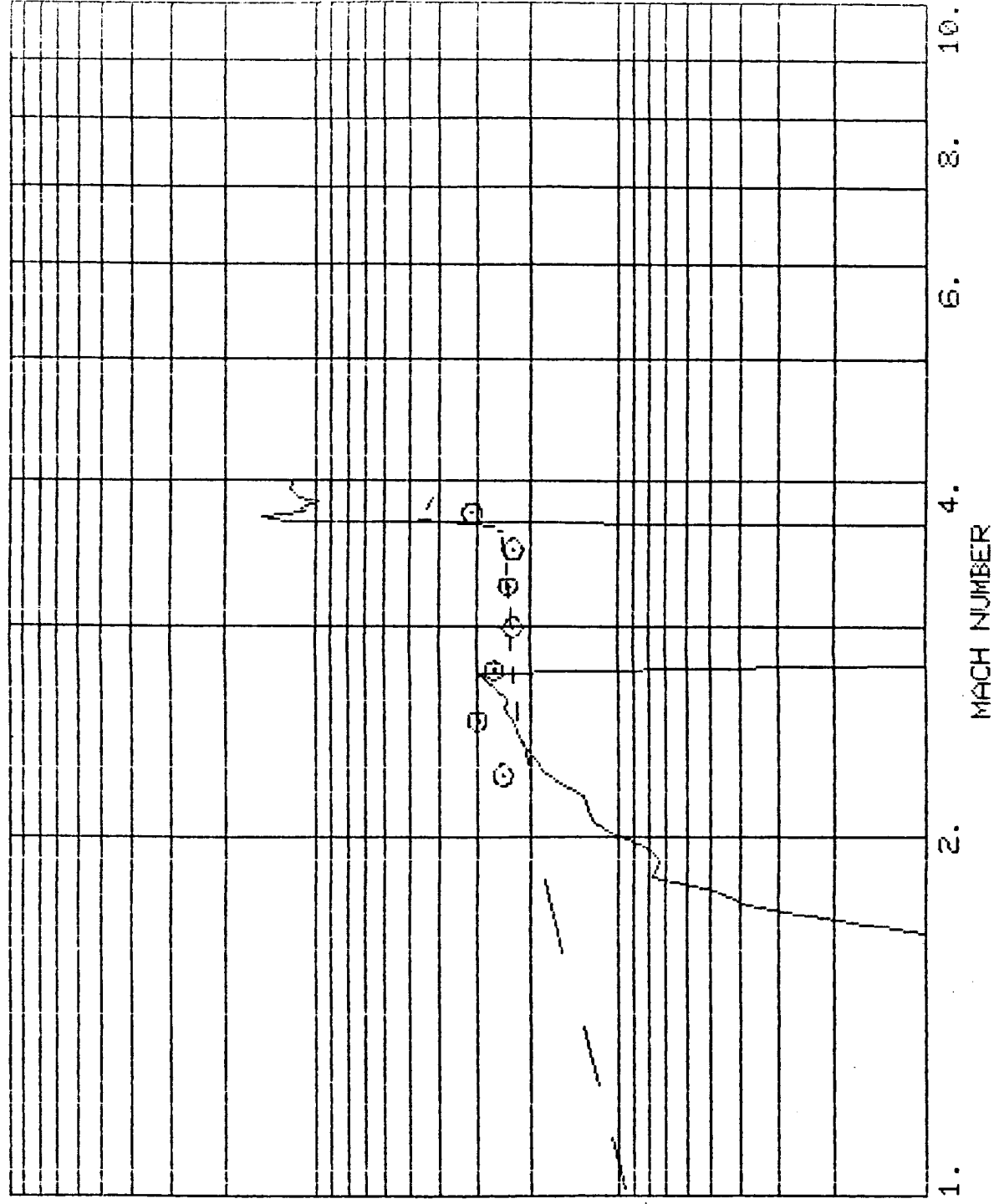


Fig. 2.25

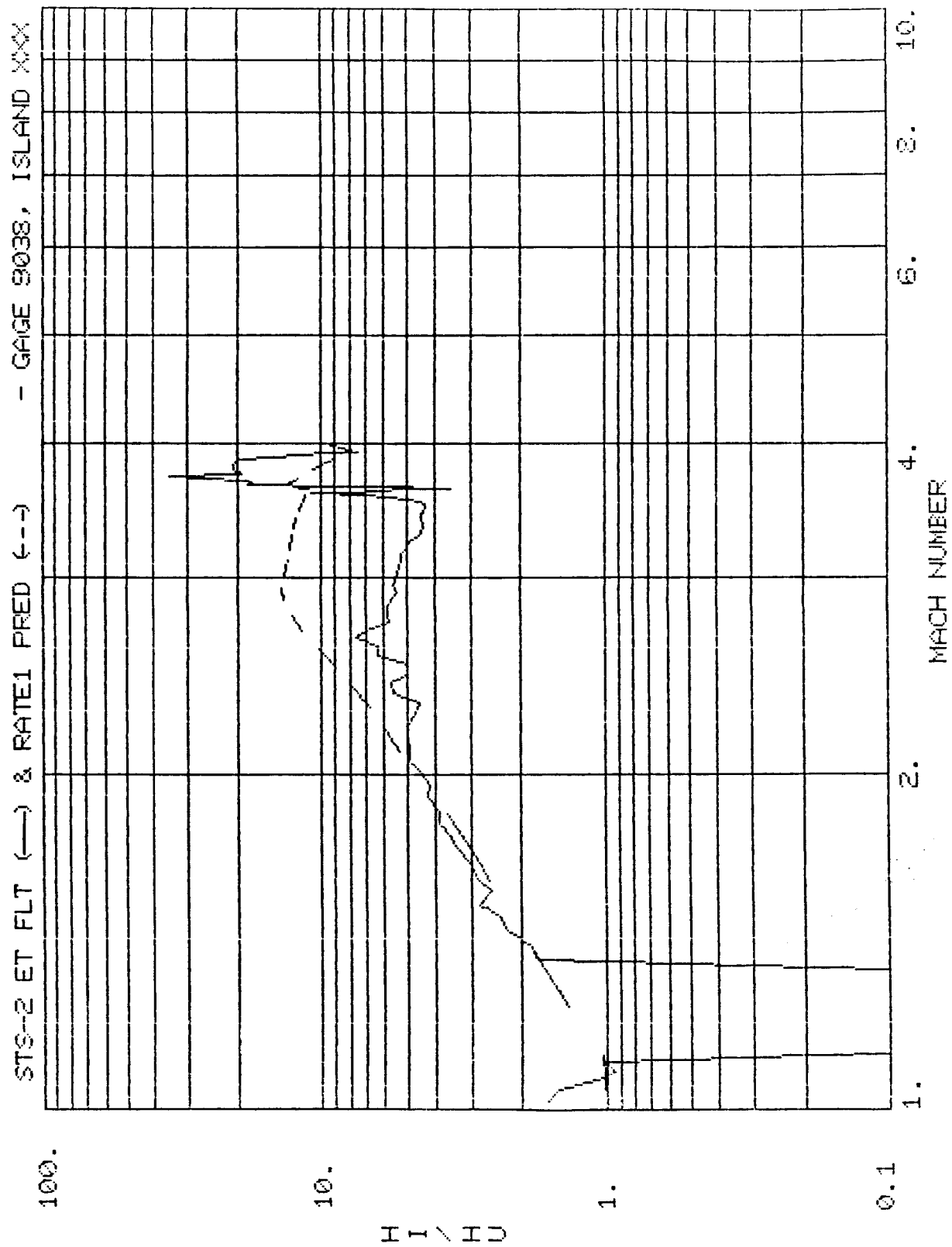


Fig. 2.26

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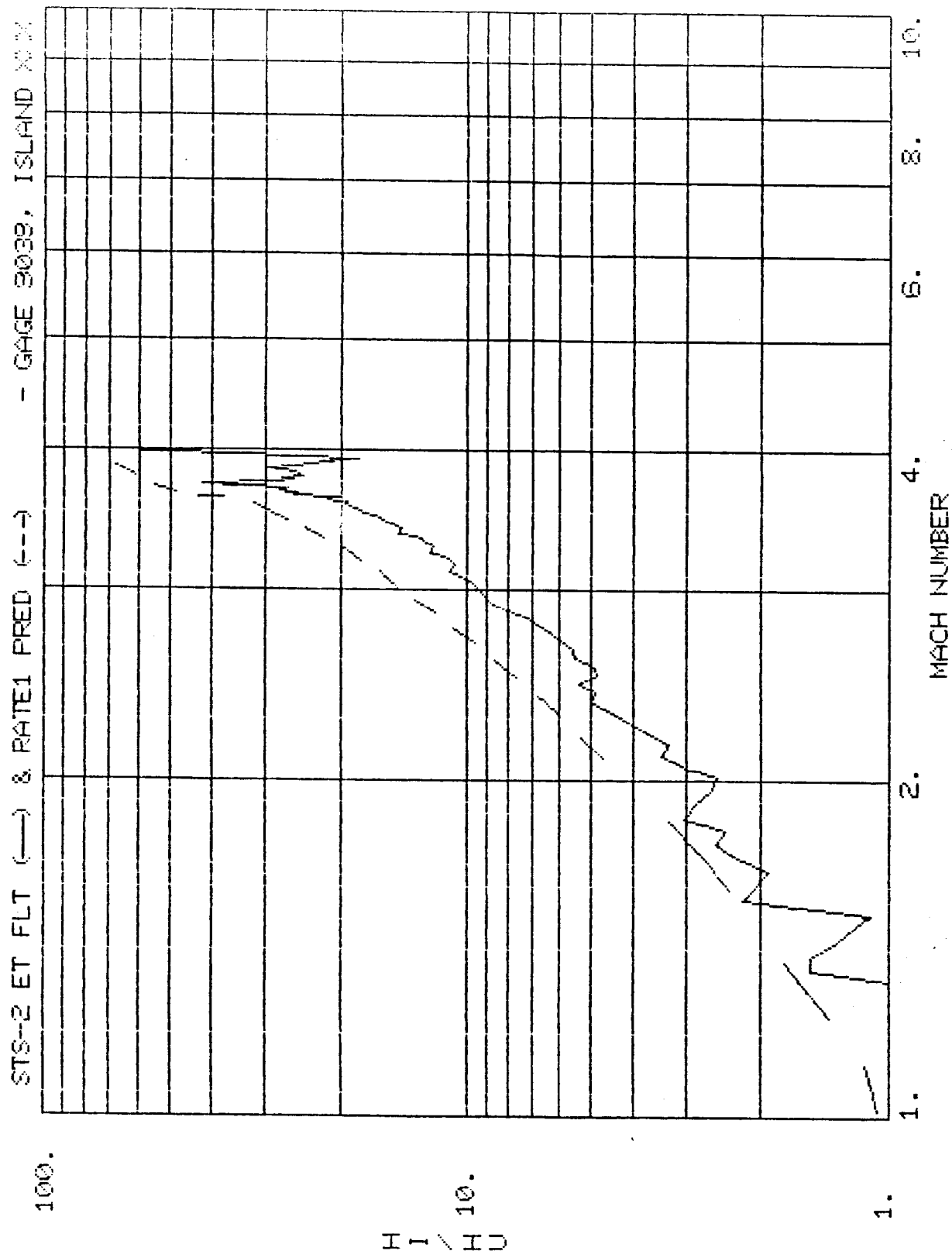


Fig. 2.27

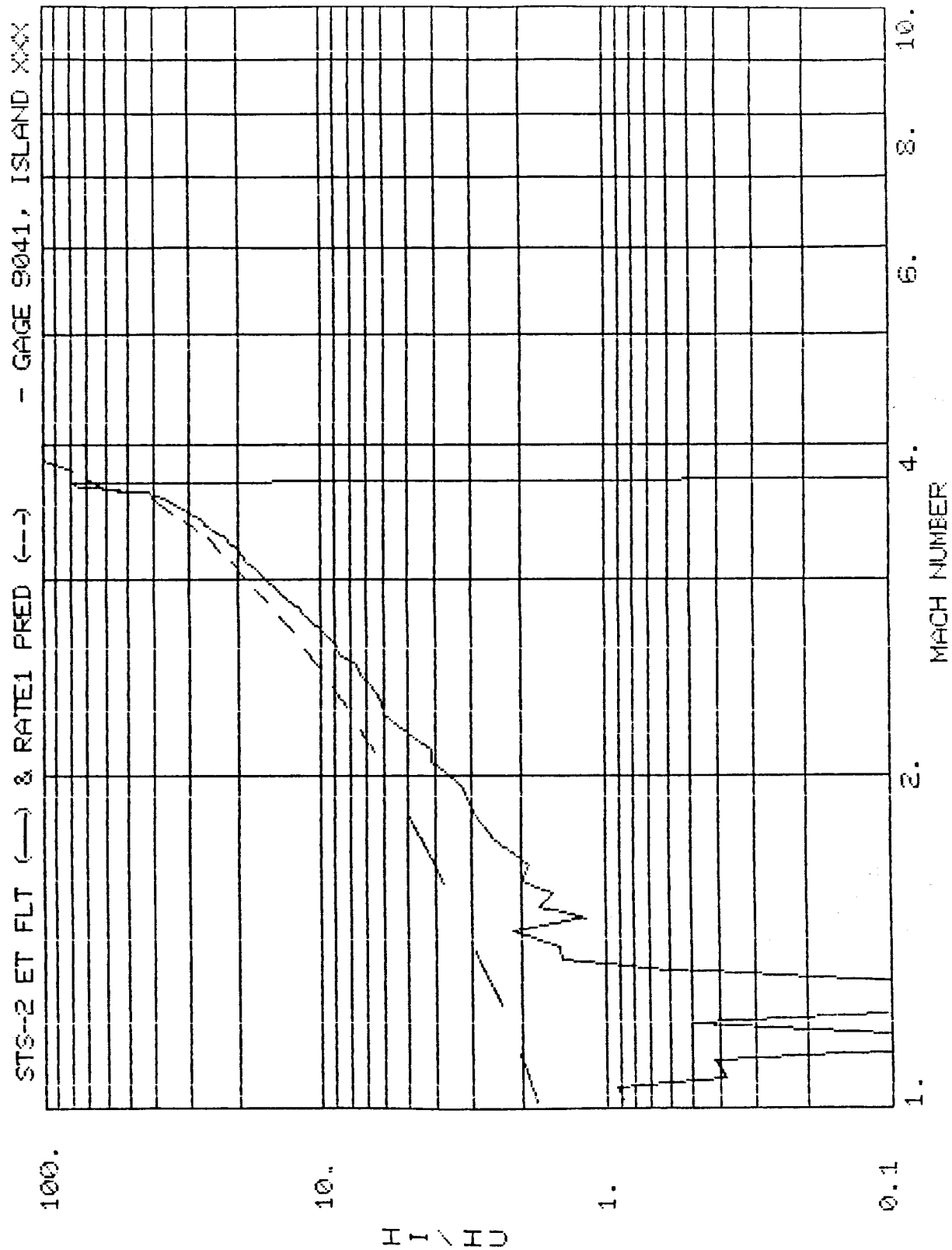


Fig. 2.28

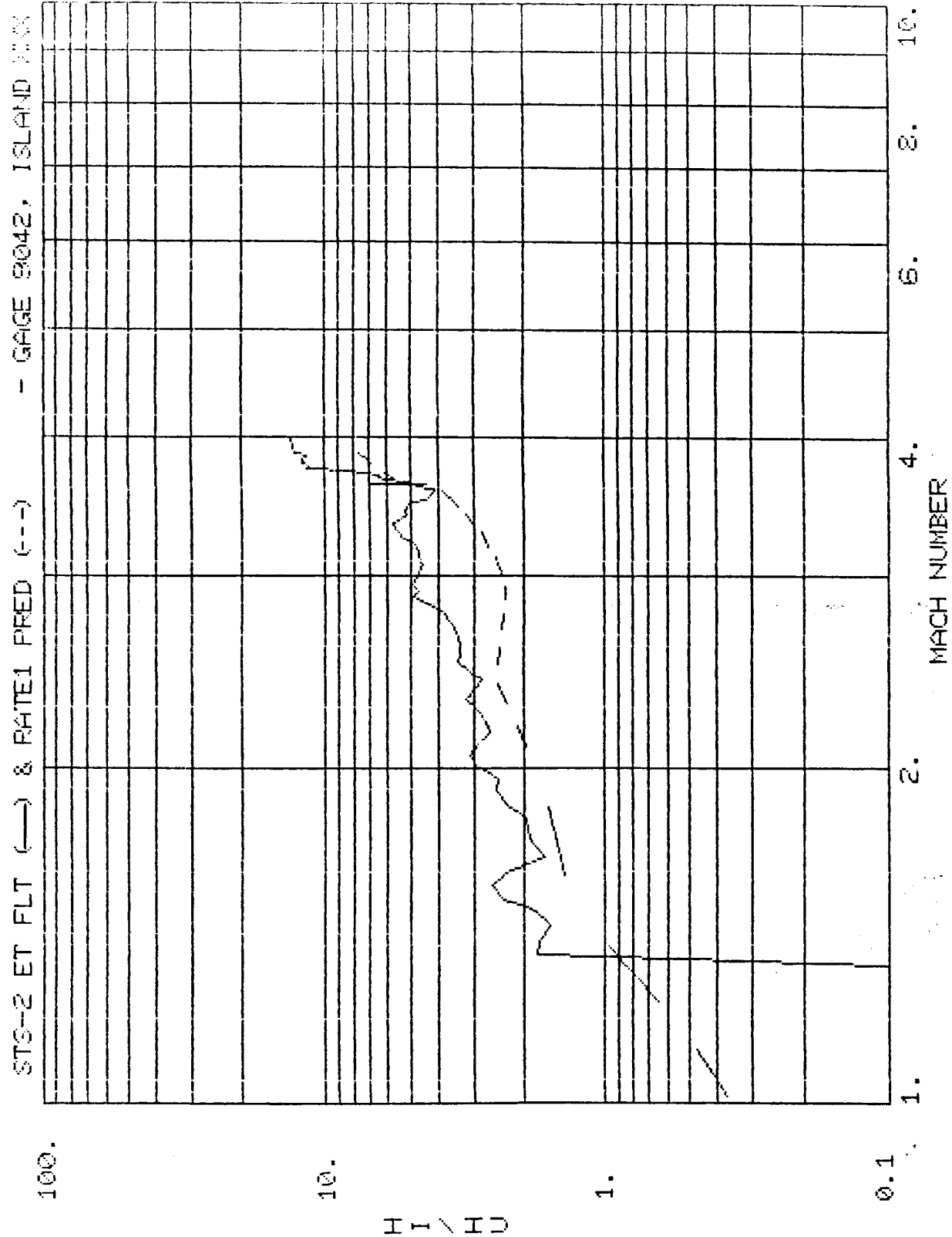


Fig. 2.29

STS-2 ET FLT (—) & RATE1 PRED (---) - GAGE 9045, ISLAND XXX

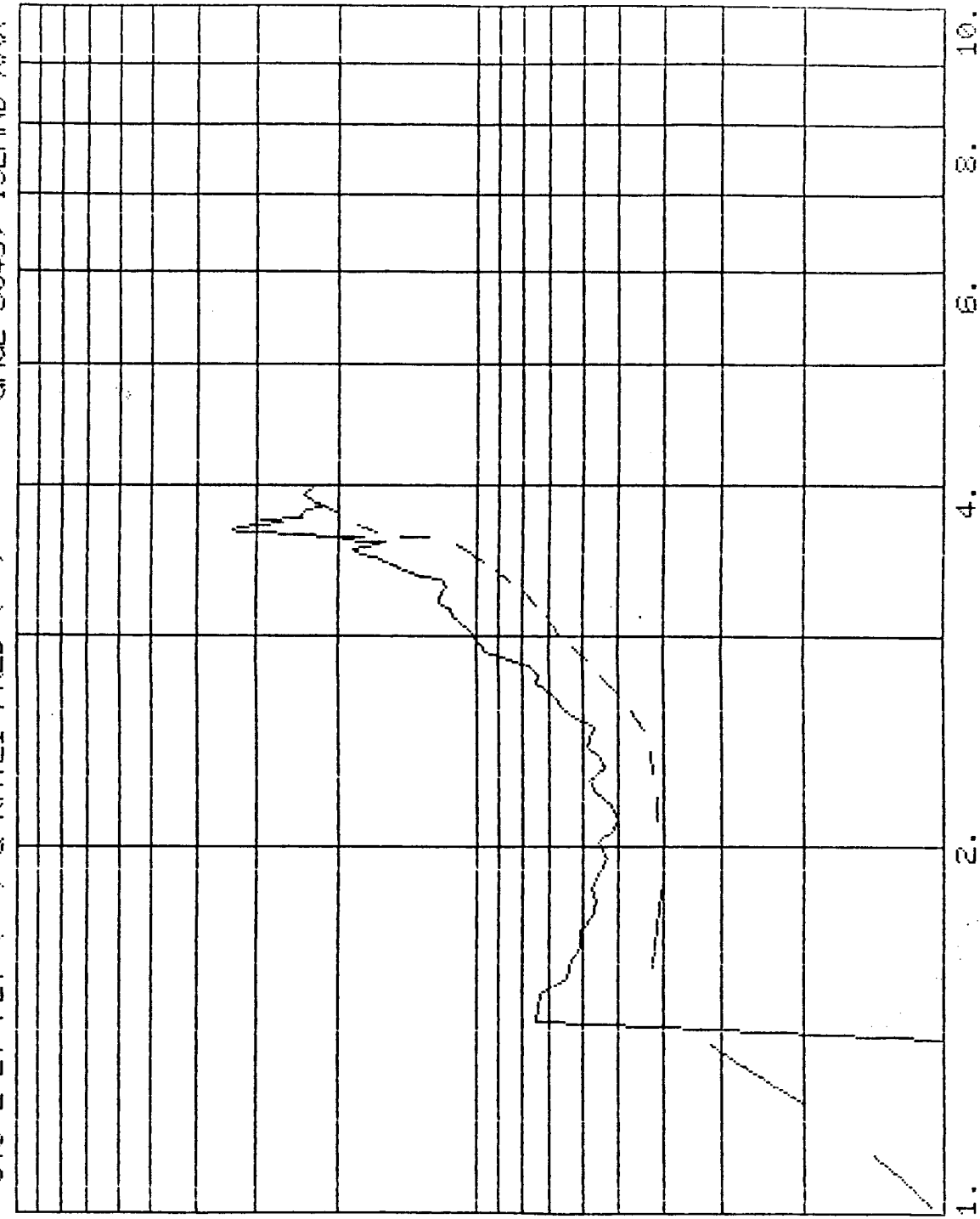


Fig. 2.30

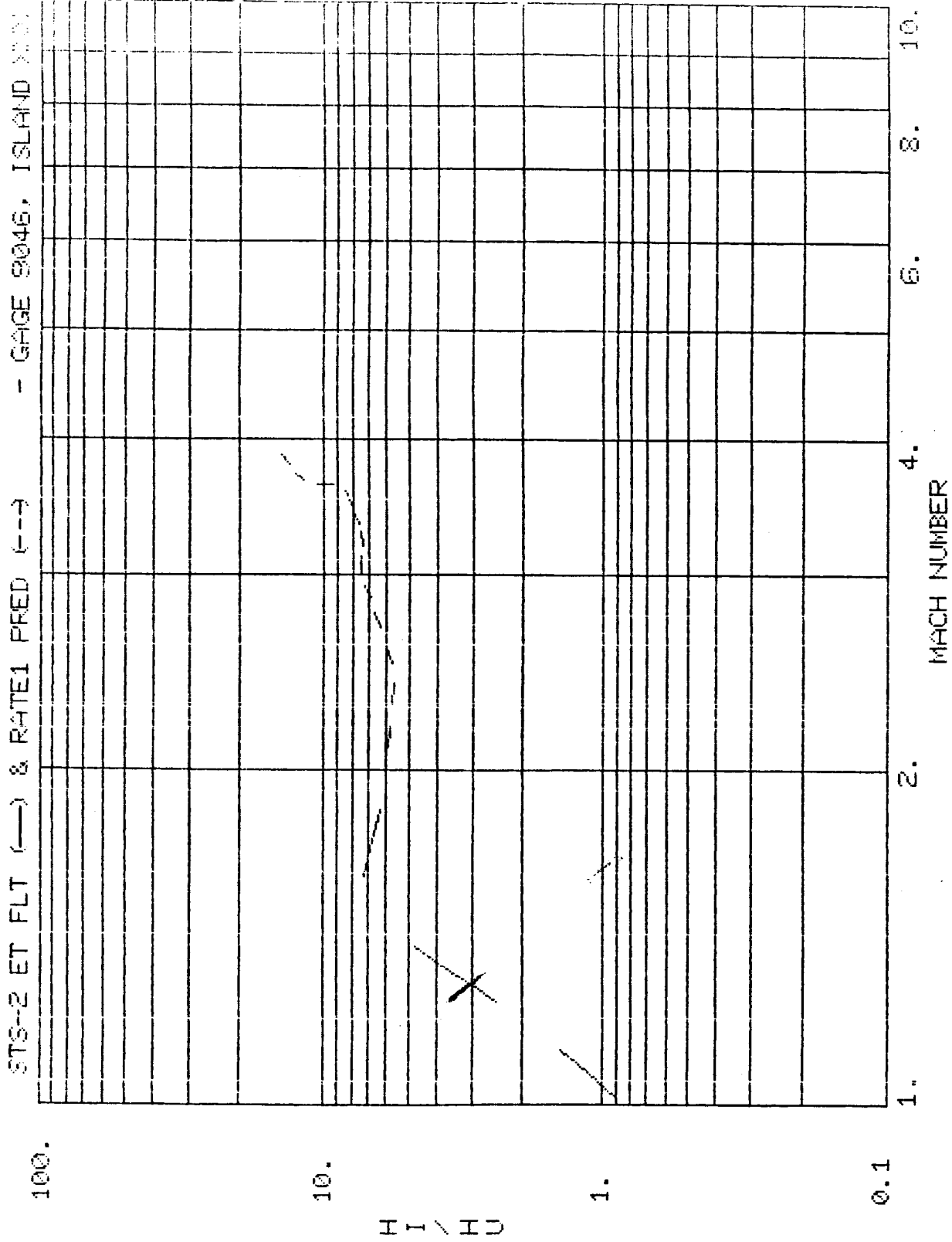


Fig. 2.31

NOTE: Bad Flight Data

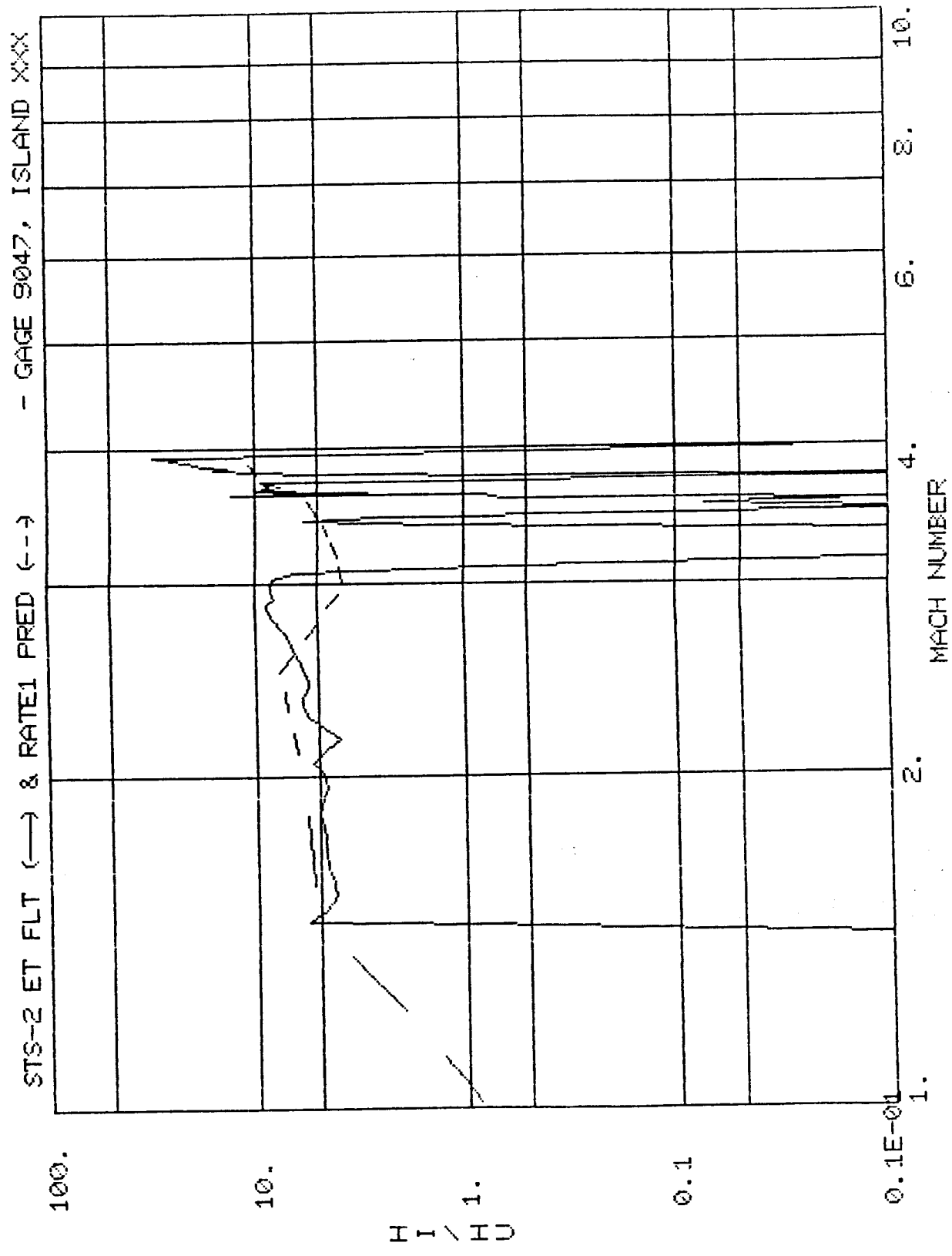


Fig. 2.32

REMTECH INC.

SET 3

STS-3 pp. 3.1 - 3.34

REMTECH INC.

Table 3.1 STS-3 DFI LOCATIONS

MEASUREMENT I.D.	XT (IN.)	THETA (DEG.)	GAGE TYPE	LOCATION
T07R9001A	350.0	180.0	Ind. Gage	40° Cone
T07R9004A	467.4	264.0	Island 2	L02 Tank
T07R9005A	467.4	174.0	Island 1	L02 Tank
T07R9007A	672.5	270.0	Island 6	L02 Tank
T07R9008A	672.5	180.0	Island 5	L02 Tank
T07R9010A	825.5	270.0	Island 8	L02 Tank
T07R9011A	976.0	25.0	Island 18	Intertank
T07R9012A	1008.0	21.0	Ind. Gage	L02 Fdin. Fairing (side)
T07R9013A	1110.4	2.5	Island 17(3)	Intertank
T07R9014A	937.4	288.6	Island 16	Intertank
T07R9015A	956.2	270.0	Island 15	Intertank
T07R9016A	937.4	251.4	Island 14	Intertank
T07R9017A	948.5	180.0	Island 12	Intertank
T07R9018A	1098.5	2.5	Island 17(2)	Intertank
T07R9019A	1084.4	2.5	Island 17(1)	Intertank
T07R9020A	1147.4	358.0	Island 27	LH2 Barrel
T07R9021A	1030.1	270.0	Island 20	Intertank
T07R9022A	1073.8	180.0	Island 23	Intertank
T07R9025A	1489.0	264.4	Island 29	LH2 Barrel
T07R9026A	1489.0	172.5	Island 28	LH2 Barrel
T07R9027A	2017.0	5.6	Island 33	LH2 Barrel
T07R9028A	2057.0	5.6	Island 35	LH2 Barrel
T07R9029A	2002.5	168.7	Island 32	LH2 Barrel
T07R9030A	2038.97	356.3	Island 34	LH2 Barrel
T07R9031A	2057.0	276.0	Island 36	LH2 Barrel
T07R9032A	2057.0	340.6	Island 37	LH2 Barrel
T07R9038A	996.0	23.0	Ind. Gage	L02 Fdin Fairing (top)
T07R9039A	1129.9	356.0	Ind. Gage	ET/ORB Fwd LH Strut
T07R9041A	959.2	270.0	Ind. Gage	Bolt Catcher
T07R9042A	2002.0	29.0	Ind. Gage	RH Thrust Strut
T07R9045A	2058.0	10.0	Ind. Gage	Aft Diag. Strut
T07R9046A	2100.0	45.0	Ind. Gage	LH Vert Strut Cable Tray
T07R9047A	2035.0	26.0	Ind. Gage	Fwd. L02 Fdin/X-Beam Cable Tray

able 3.2 STS-3 ET INTERFERENCE FACTORS FROM THE IH-97A WIND TUNNEL DATA BASE
GAGE ! IH97A HI/HU @ MACH NUMBER

NO. !	NO. !	2.25 !	2.50 !	2.75 !	3.00 !	3.25 !	3.50 !	3.75
9001	5029	1.020	0.966	1.106	2.072	1.660	1.110	0.390
9004	5031	1.011	0.994	0.975	0.970	0.967	0.956	0.917
9005	5030	0.958	0.951	1.005	0.914	0.928	0.924	0.845
9007	5033	0.930	0.948	1.029	0.997	0.967	0.874	0.849
9008	5032	1.132	1.145	1.122	1.169	1.129	1.130	1.043
9010	5034	0.459	0.445	0.440	0.420	0.341	0.329	0.356
9011	5042	1.129	1.063	0.857	0.707	1.076	1.650	1.429
9013	5041	—	—	—	4.092	3.119	3.207	3.438
9014	5038	3.655	3.498	4.058	—	5.193	5.962	6.272
9015	5258	4.675	6.596	—	7.332	8.050	11.900	9.458
9016	5036	4.576	4.055	3.999	4.398	4.802	5.773	5.482
9017	5035	0.666	0.641	0.650	0.747	0.753	0.787	0.810
9018	5039	3.345	3.924	3.862	—	3.071	2.806	3.119
9019	5040	2.955	3.338	3.003	2.742	2.366	1.956	2.199
9020	5250	2.864	3.400	4.367	5.020	5.972	6.213	5.010
9021	5043	0.157	0.325	0.476	0.661	1.006	1.156	1.157
9022	5044	1.238	1.224	0.876	0.695	0.704	0.744	0.774
9023	5249	3.338	3.872	3.880	4.152	4.725	4.436	3.109
9024	5251	1.027	1.124	1.729	1.540	1.768	1.973	1.868
9025	5046	1.127	1.104	0.855	0.819	0.939	0.682	0.620
9026	5045	0.700	0.775	0.832	0.808	0.792	0.793	0.834
9027	5048	1.113	1.227	1.767	1.893	1.979	1.710	2.565
9028	5050	1.131	1.340	1.591	1.861	2.202	2.416	2.213
9029	5047	0.464	0.439	0.396	0.388	0.417	0.039	0.140
9030	5049	3.210	2.124	2.618	3.247	3.320	6.665	3.028
9031	5051	3.305	3.153	4.875	2.822	6.186	7.201	7.136
9032	5052	2.480	2.939	2.619	3.687	3.980	3.190	4.431
9033	5252	1.556	1.254	1.745	1.398	0.953	1.422	0.726

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9001, ISLAND XXX
10.

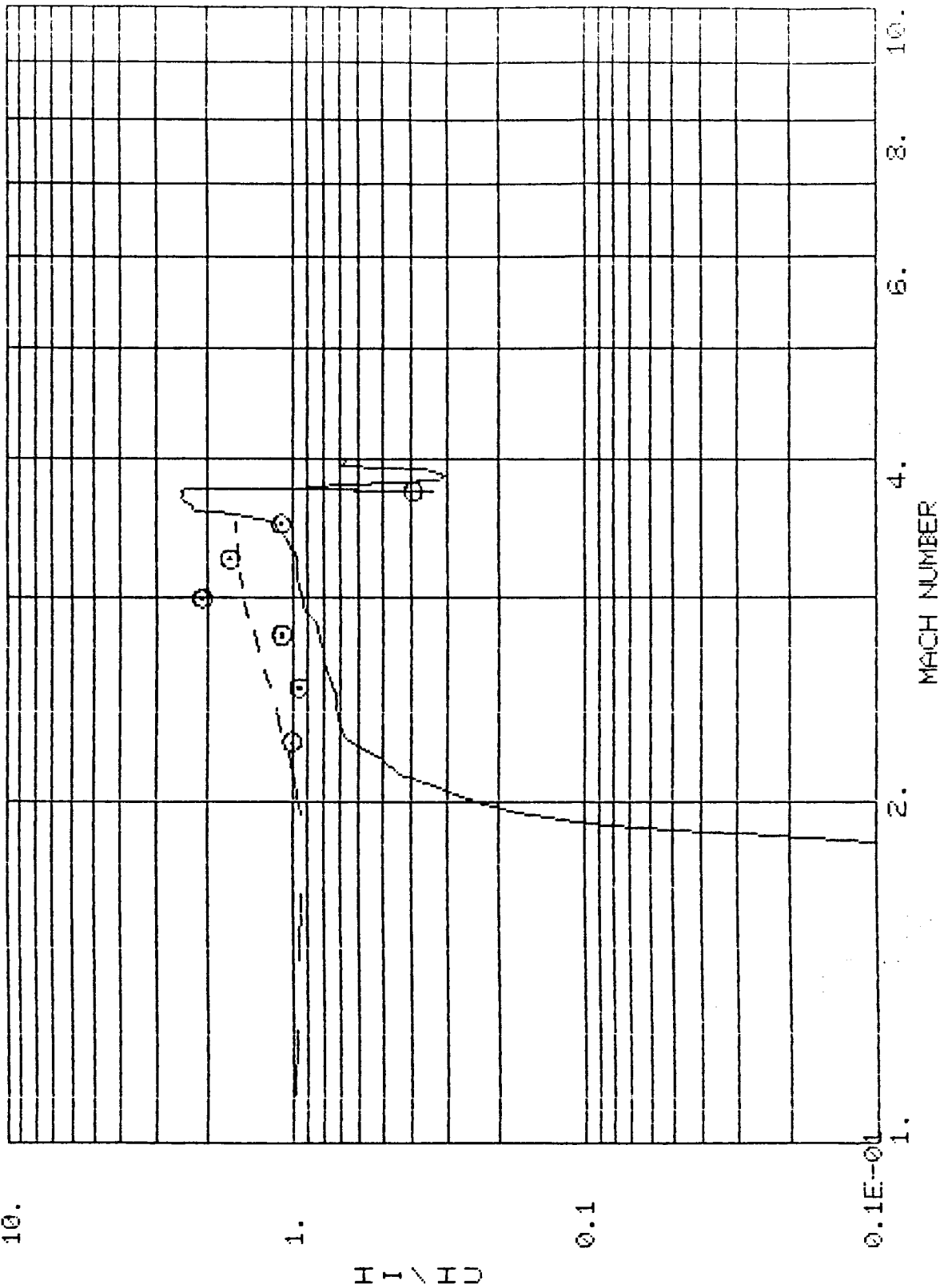


Fig. 3.1

STS-3 ET FLT (—), RATE1 PRED (---), & IH37-A (o) - GAGE 9004, ISLAND 2
10.

H I / H D 1.

0.1

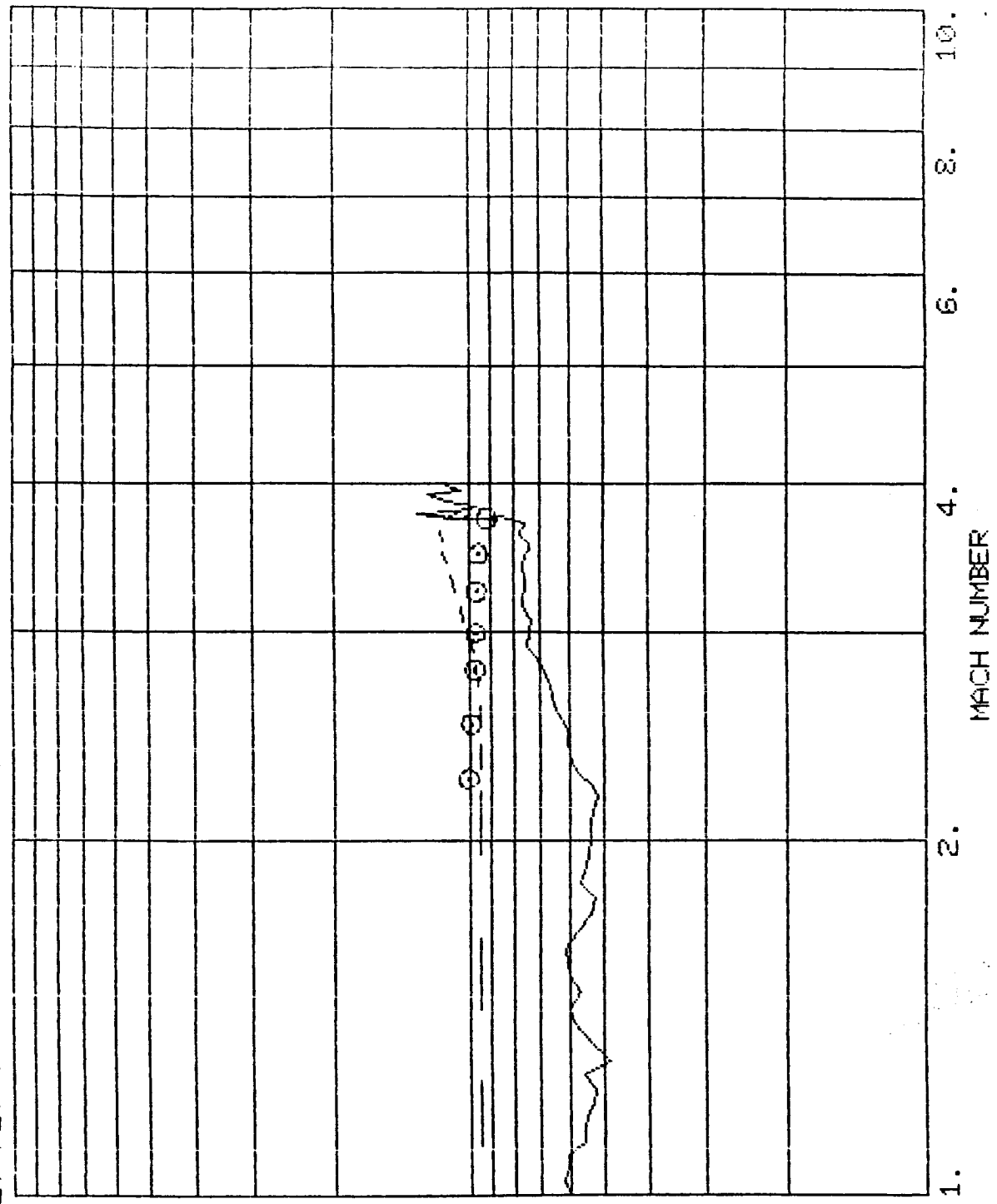


Fig. 3.2

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9005, ISLAND 1

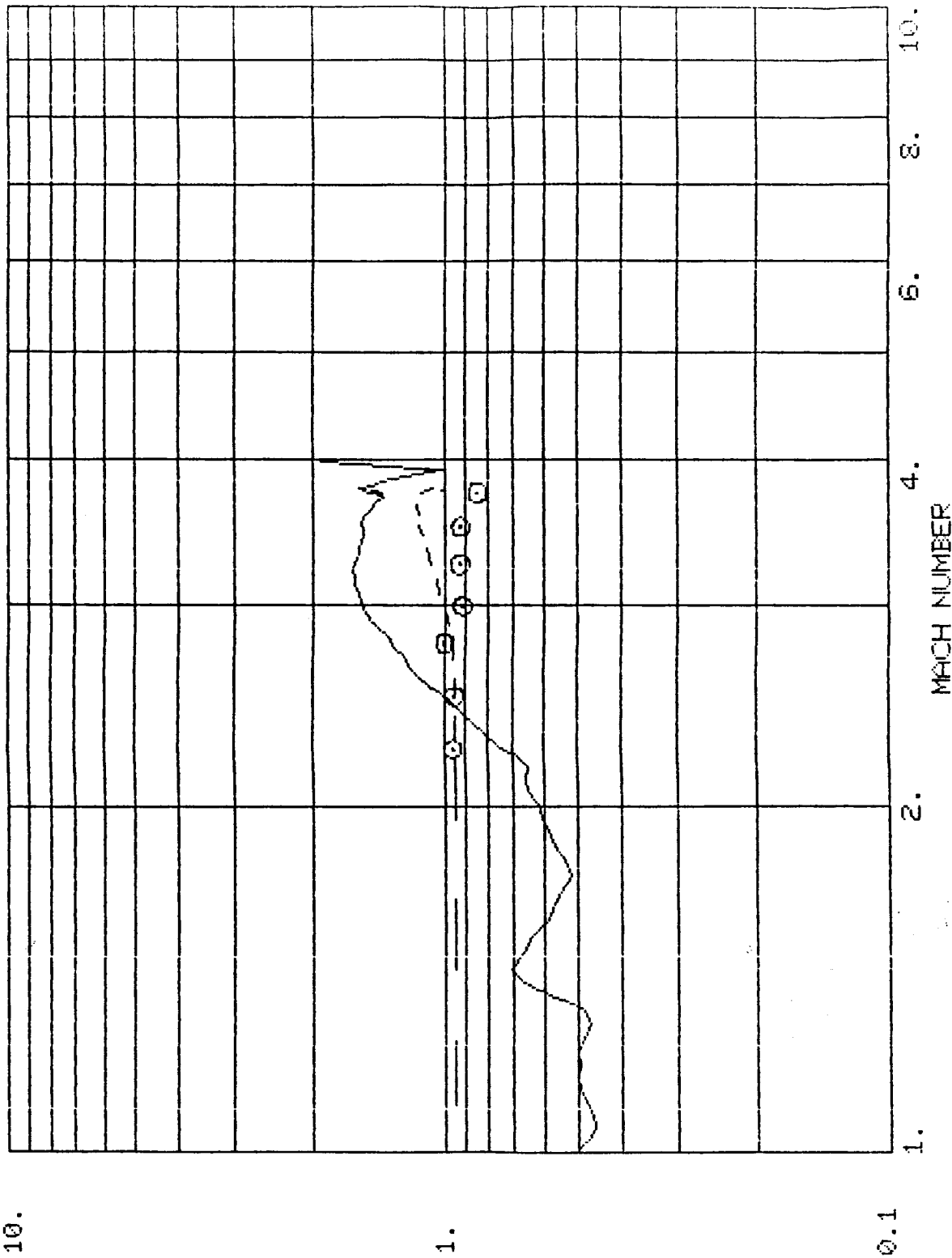


Fig. 3.3

STS-3 ET FLT (—), RATE1 PRED (---), & IH37-A (O) - GAGE 9007, ISLAND 6.
10.

H I \ HD
1.

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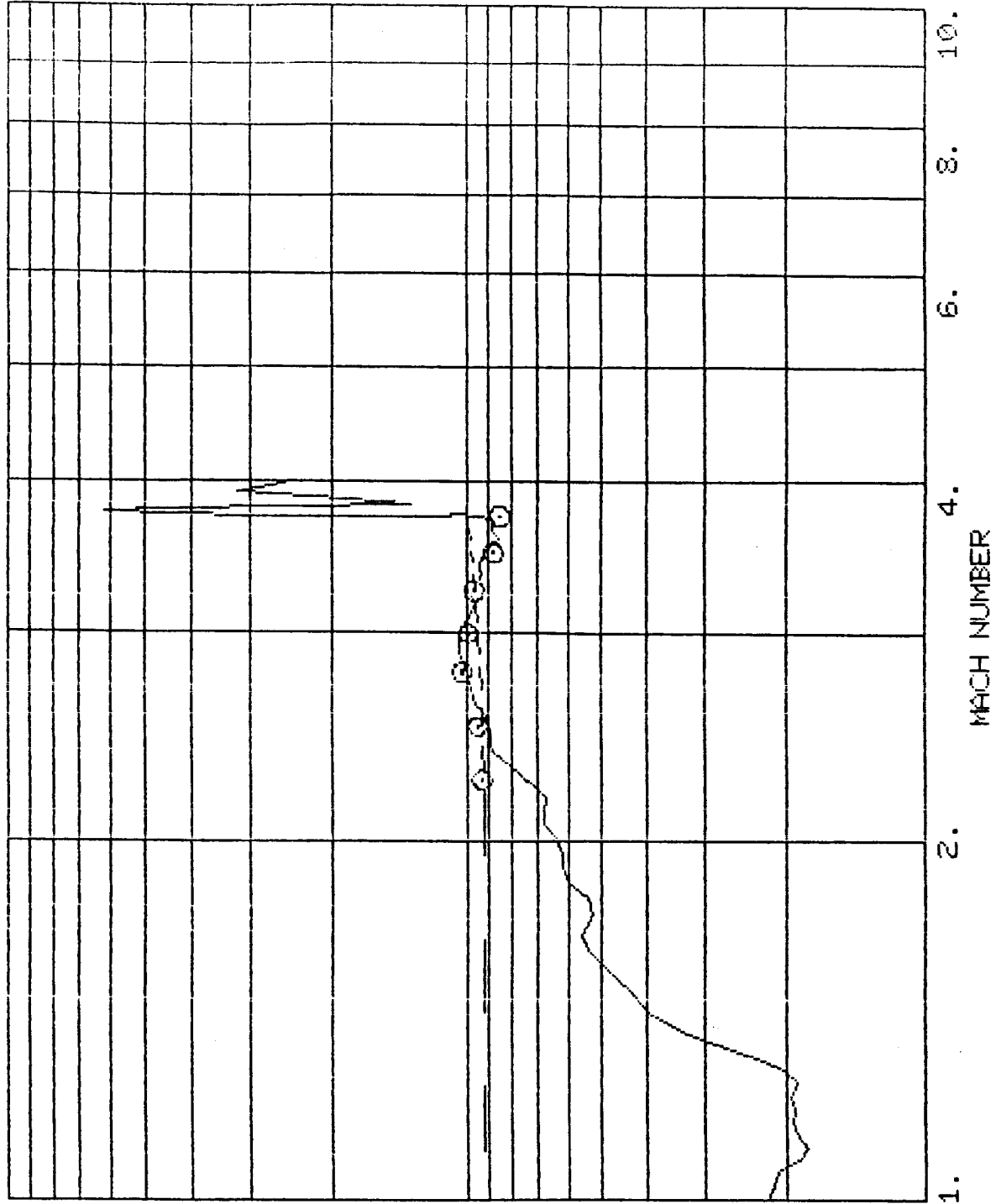


Fig. 3.4

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9008, ISLAND 5

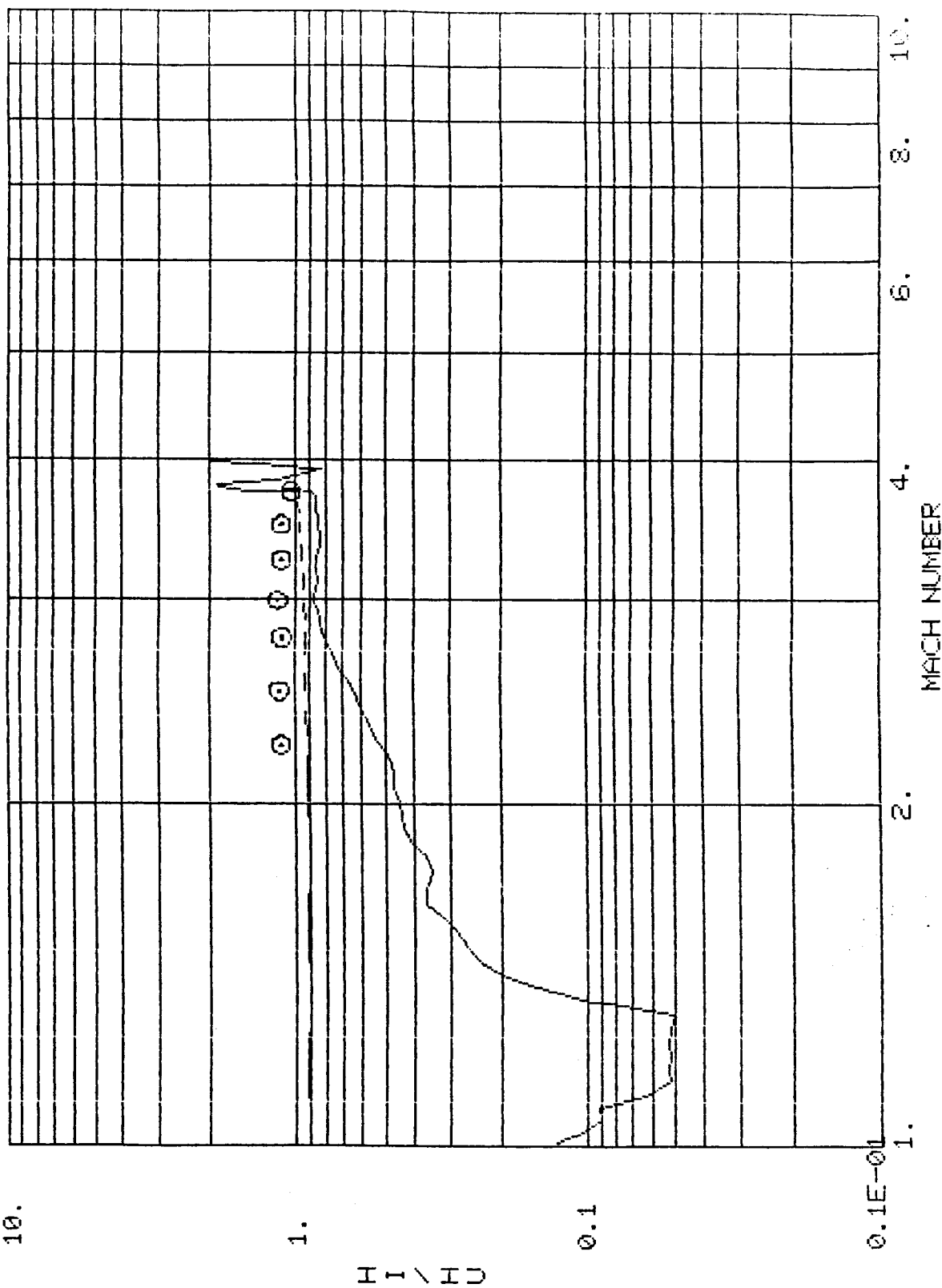


Fig. 3.5

STS-3 ET FLT (—), RATE1 PRED (---), & IH87-A (O) - GAGE 8010, ISLAND 8
100.

10.

$H I / H D$

1.

0.1

10.

8.

6.

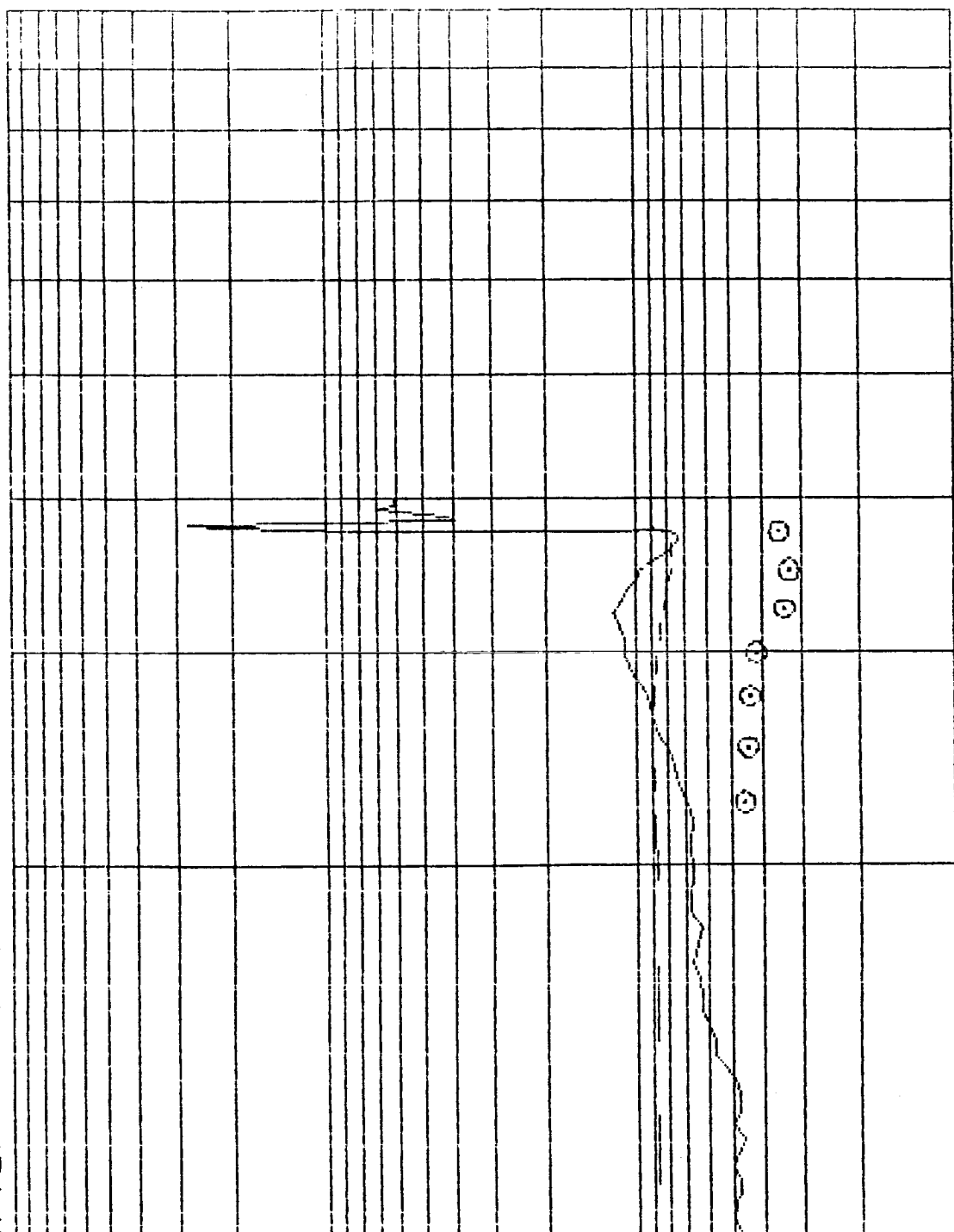
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2.

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MACH NUMBER

Fig. 3.6



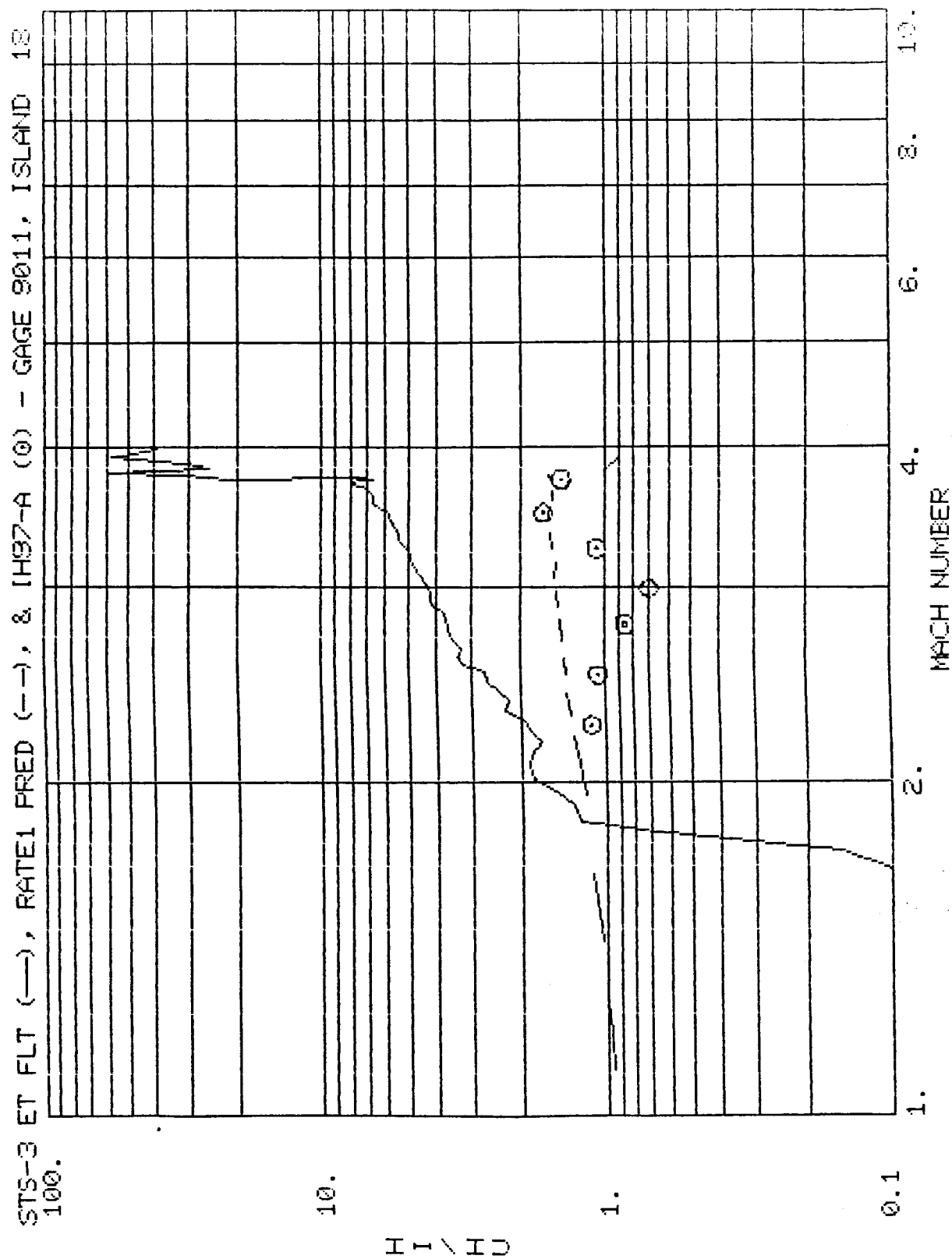


Fig. 3.7

STS-3 ET FLT (—) & RATE1 PRED (---) - GAGE 9012, ISLAND XXX

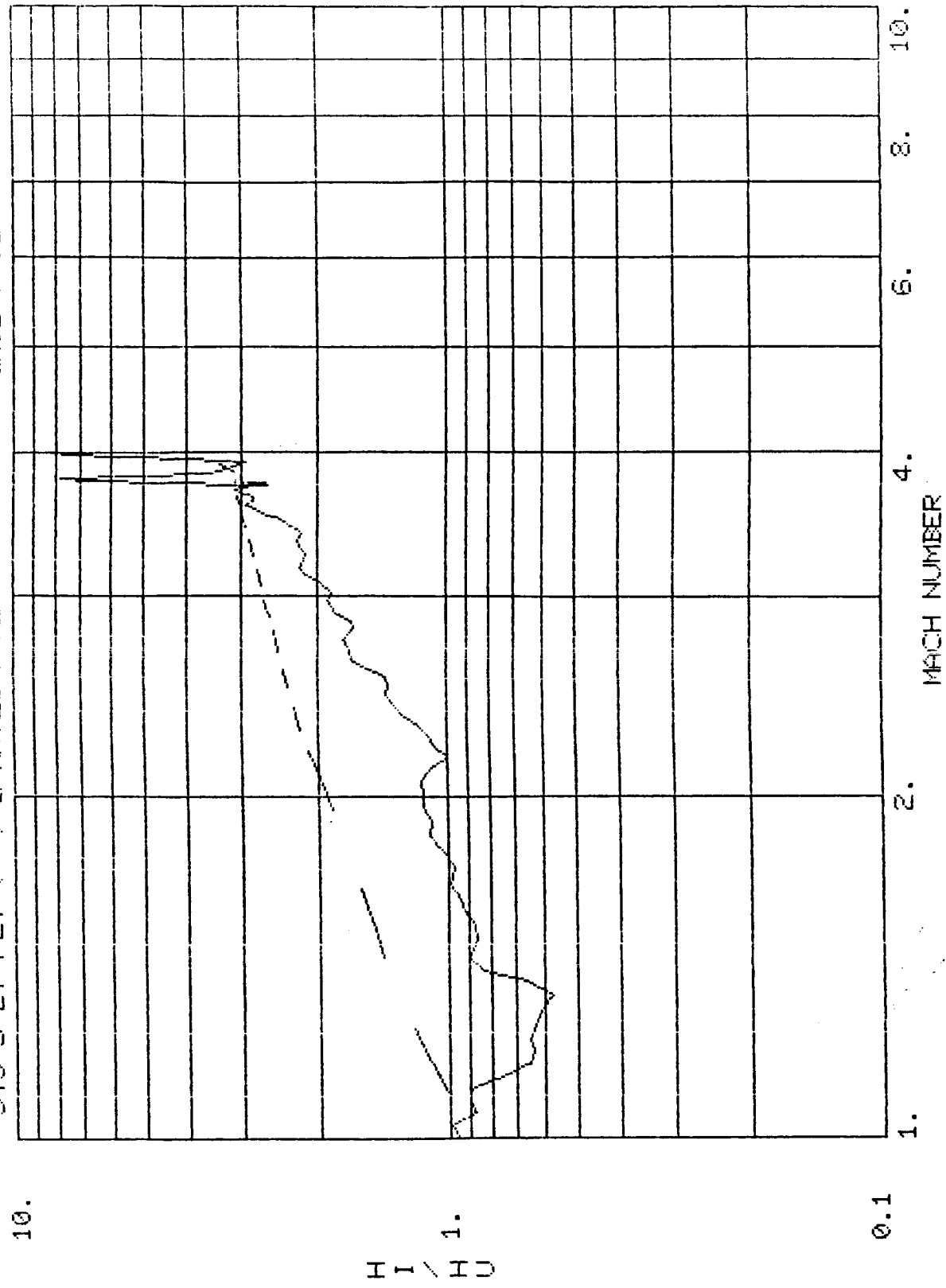


Fig. 3.8

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9013, ISLAND 173
100.

H_I / H_D
10.

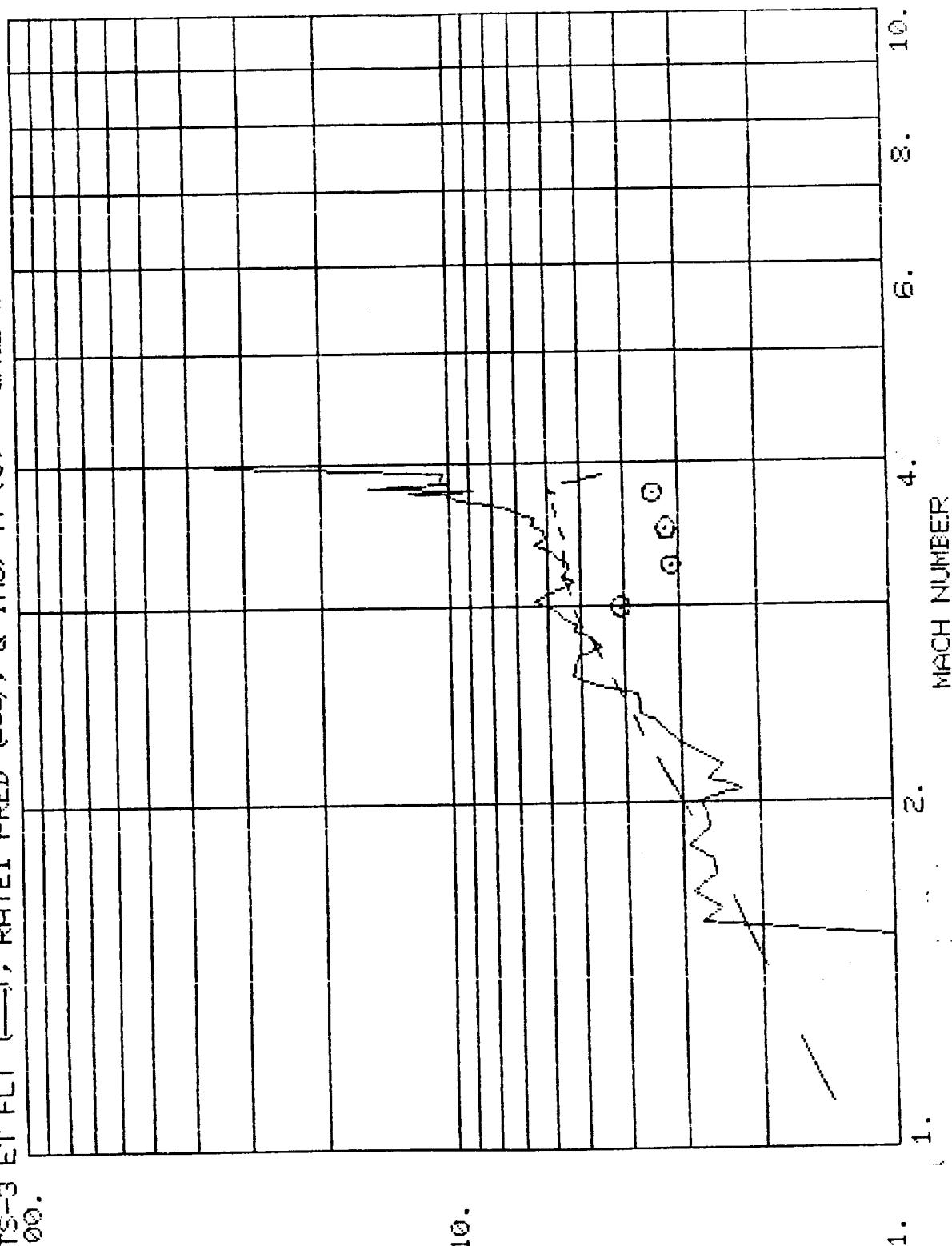


Fig. 3.9

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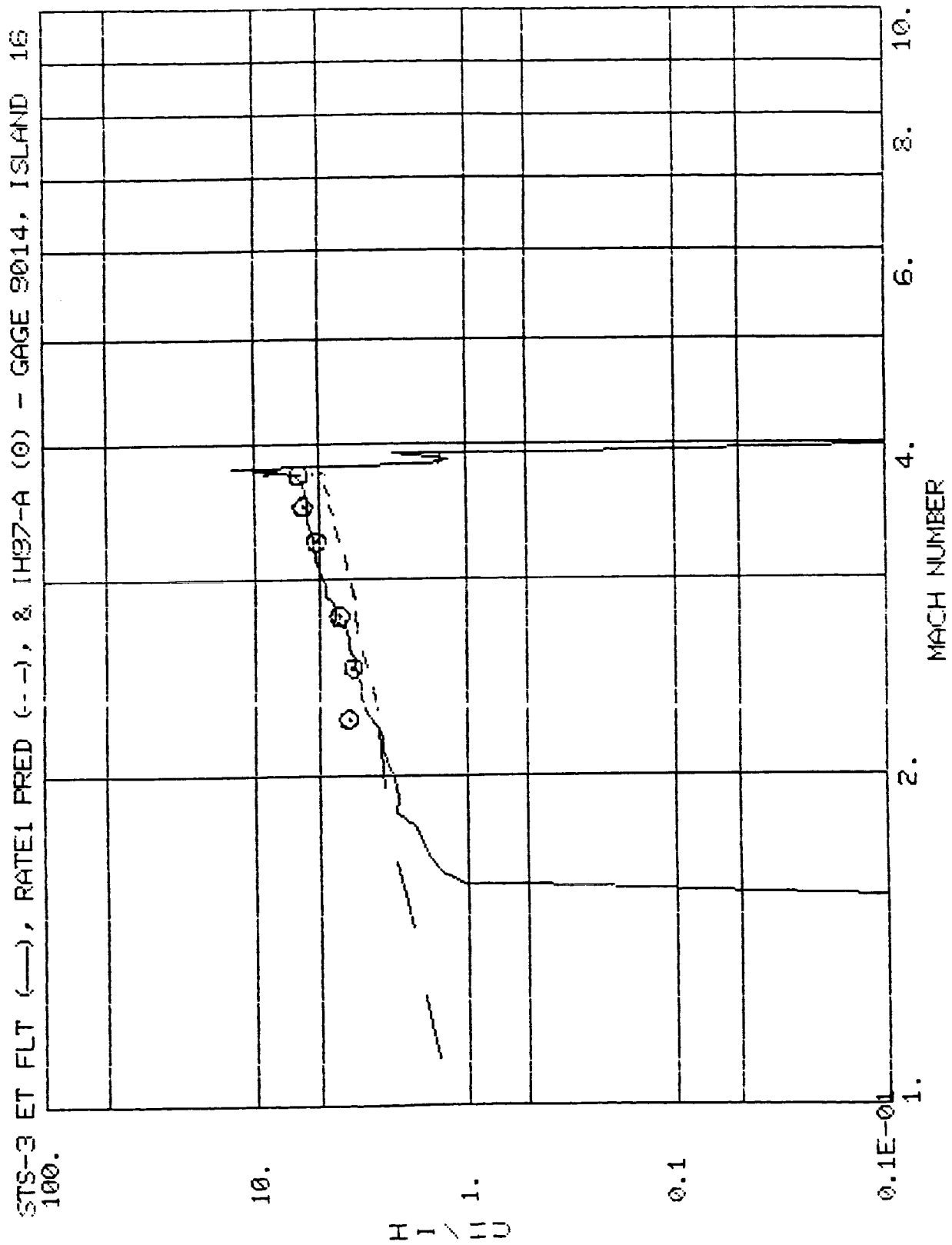


Fig. 3.10

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9015, ISLAND 15
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H I / H D 10.

1.

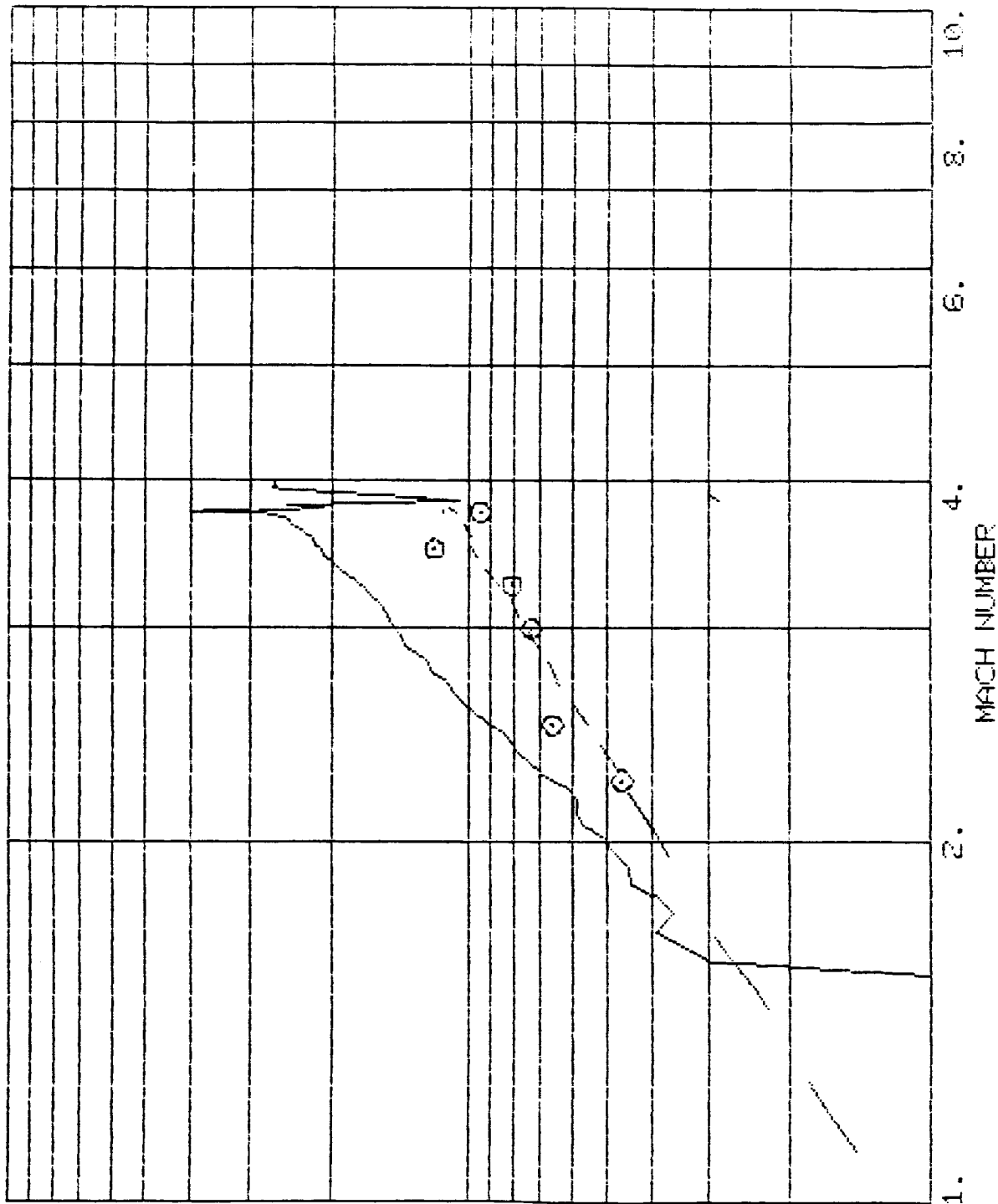


Fig. 3.11

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9016, ISLAND 14
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H_I / H_D 10.

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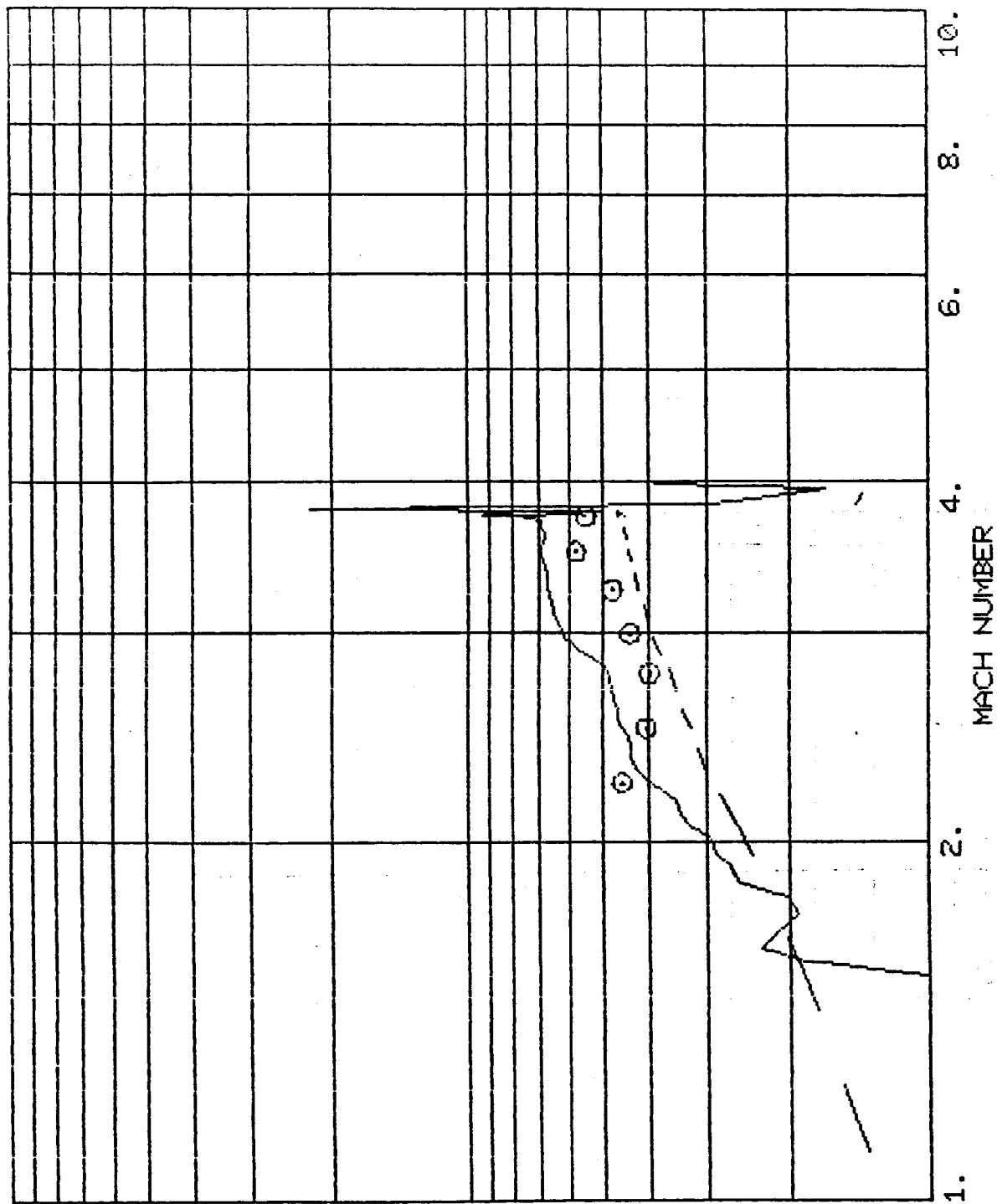


Fig. 3.12

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9017, ISLAND 12

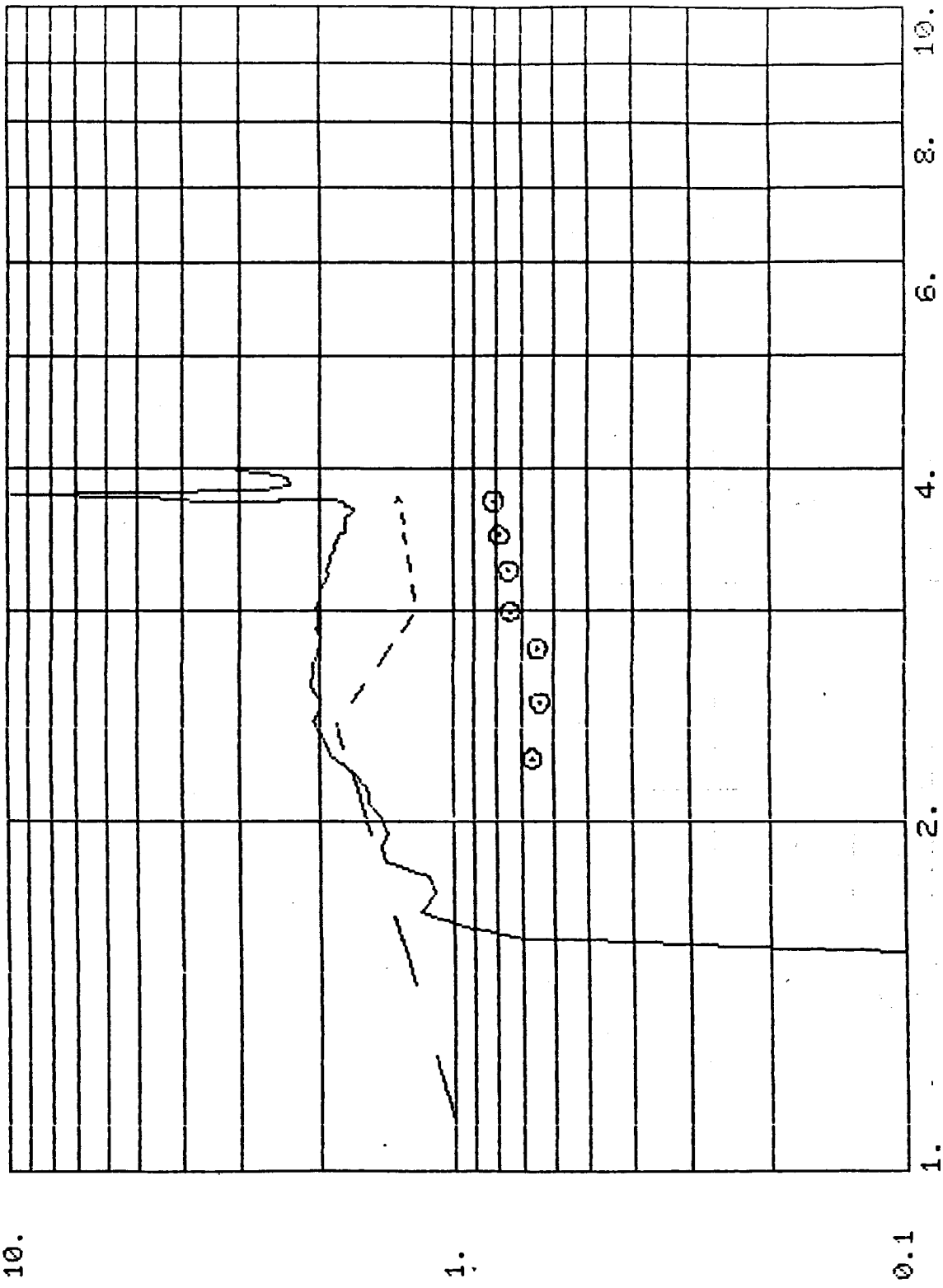


Fig. 3.13

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9018, ISLAND 172
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H_I / H_D
10.

1.

10.

2.

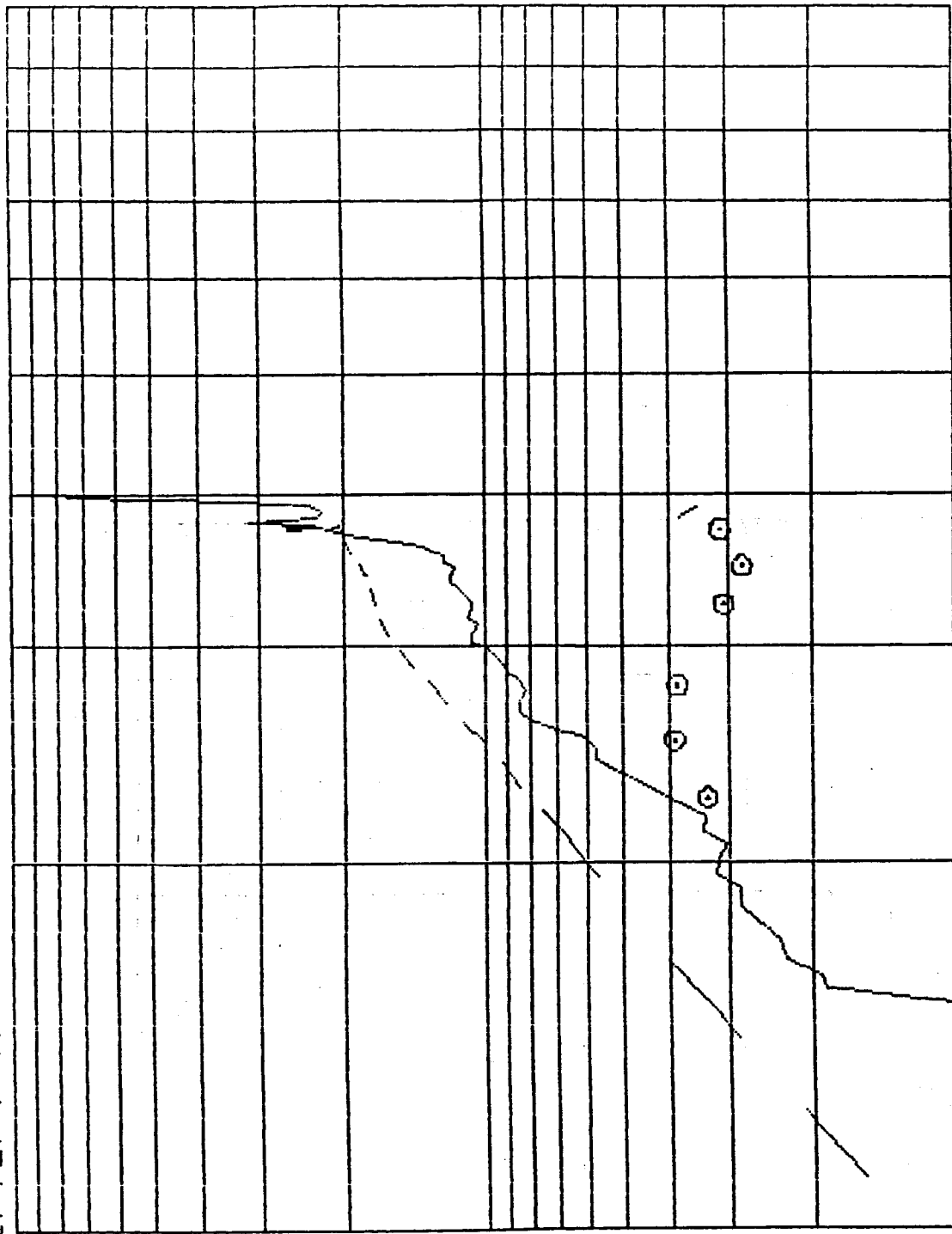
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6.

8.

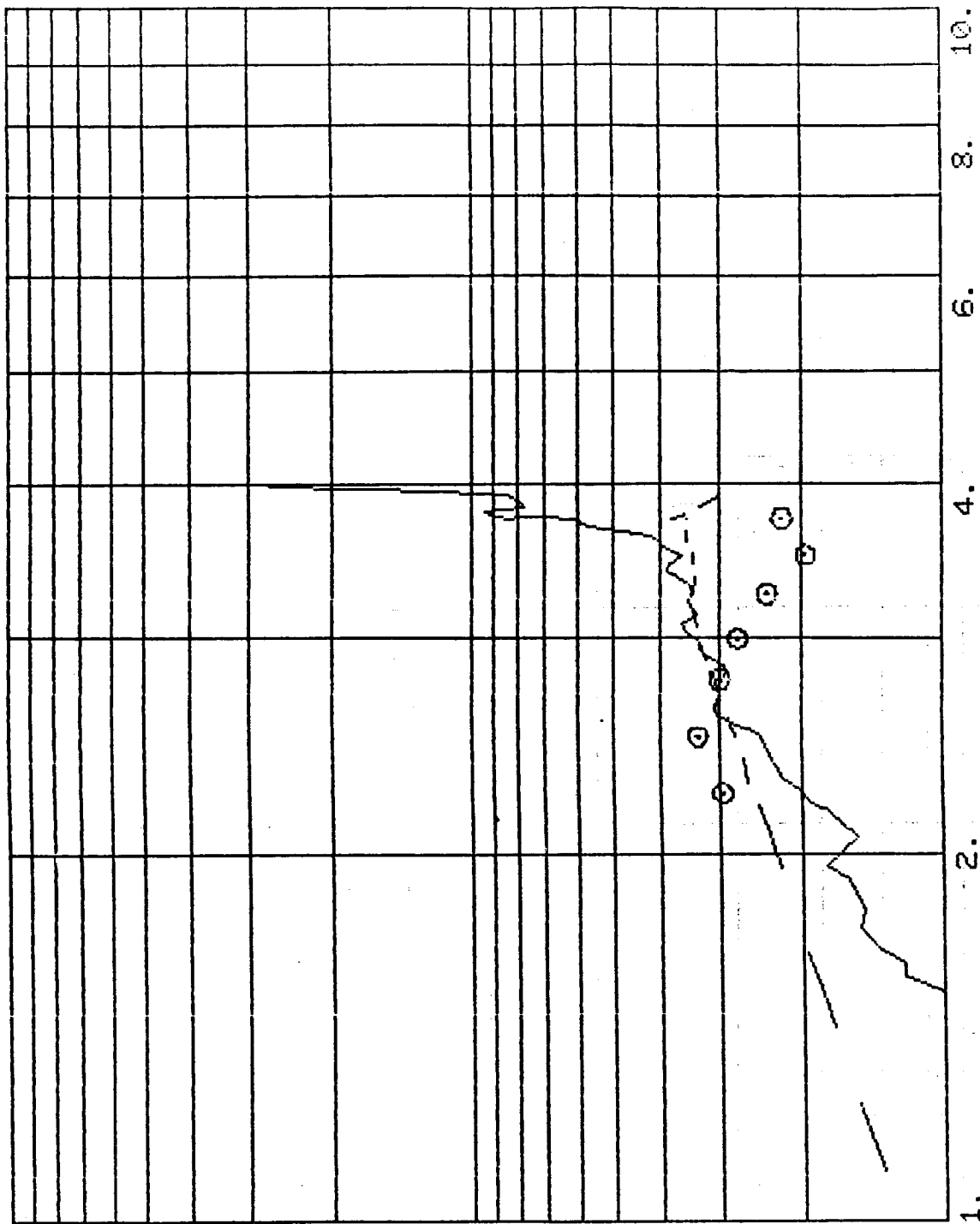
MACH NUMBER

Fig. 3.14



STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9019, ISLAND 171
100.

$\frac{H_I}{H_U} \times 10.$



MACH NUMBER

Fig. 3.15

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9021, ISLAND 20
10.

H_I / H_D 1.

0.1

1.

2.

4.

6.

8.

10.

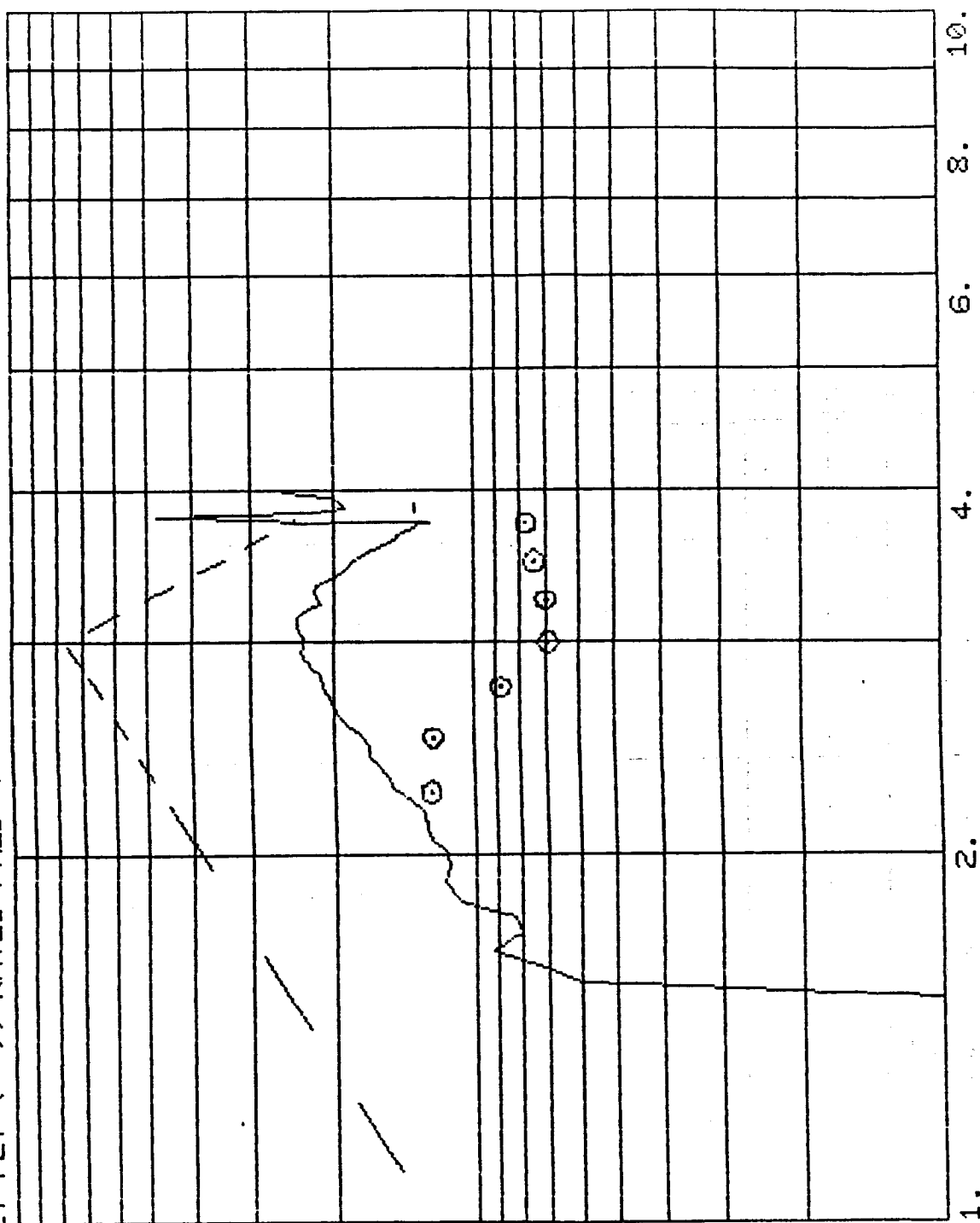
MACH NUMBER

Fig. 3.16

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9022, ISLAND 23
10.

H I \ HD
1.

0.1



MACH NUMBER

Fig. 3.17

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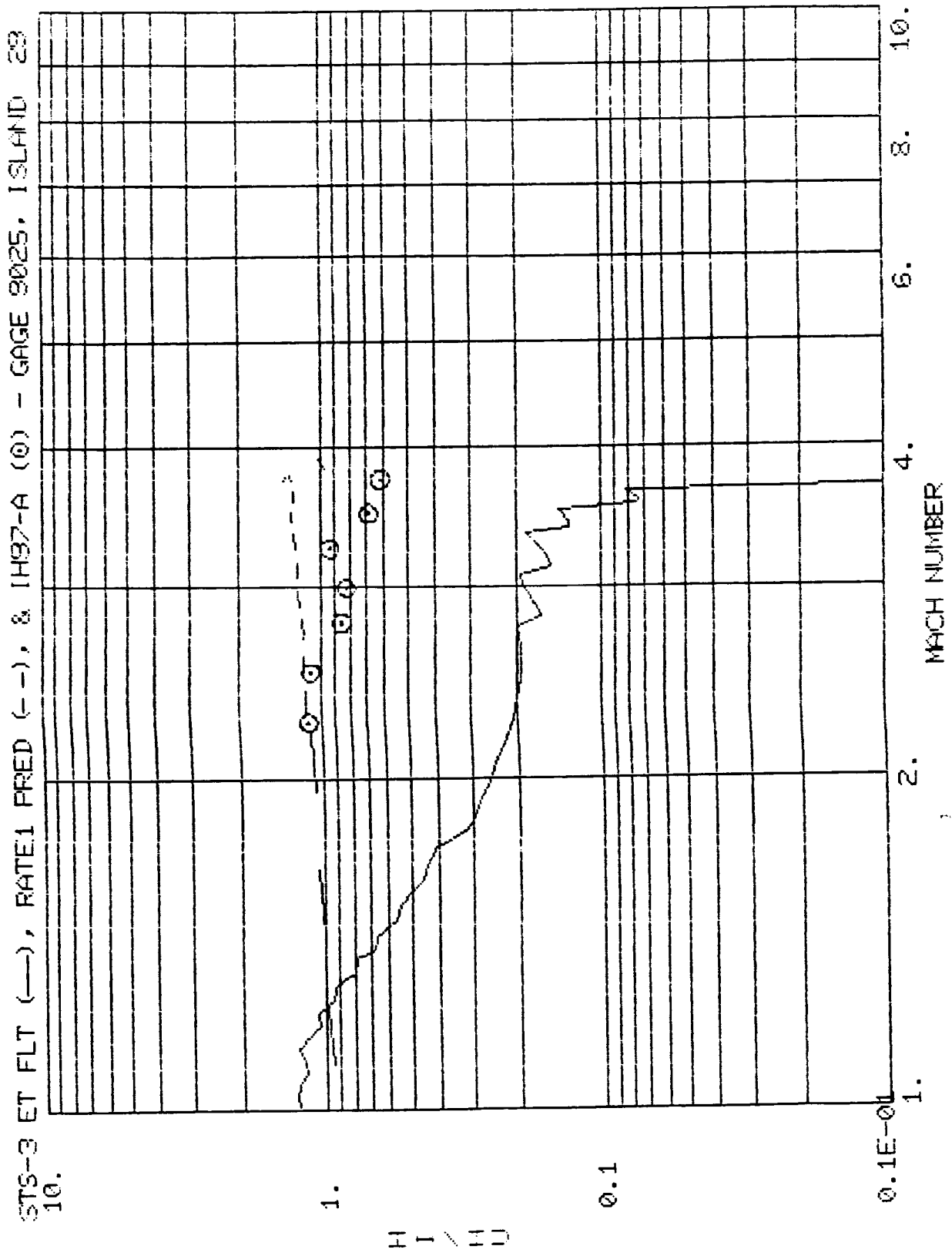


Fig. 3.18

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9026, ISLAND 28
10.

H
I
/ H
D 1.

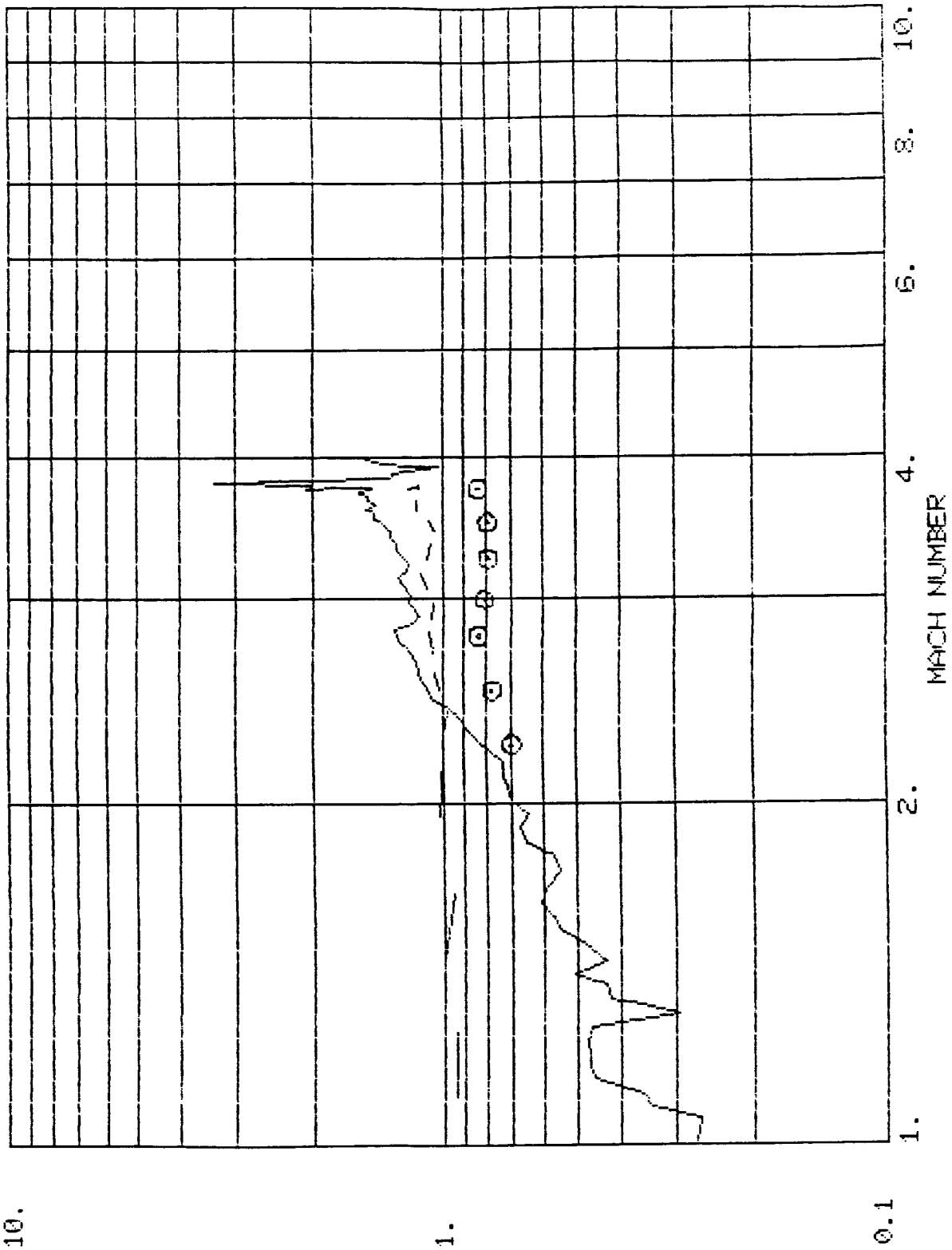


Fig. 3.19

STS-3 ET FLT (—), RATE1 PRED (---), & IH37-A (○) - GAGE 9027, ISLAND 33
10.

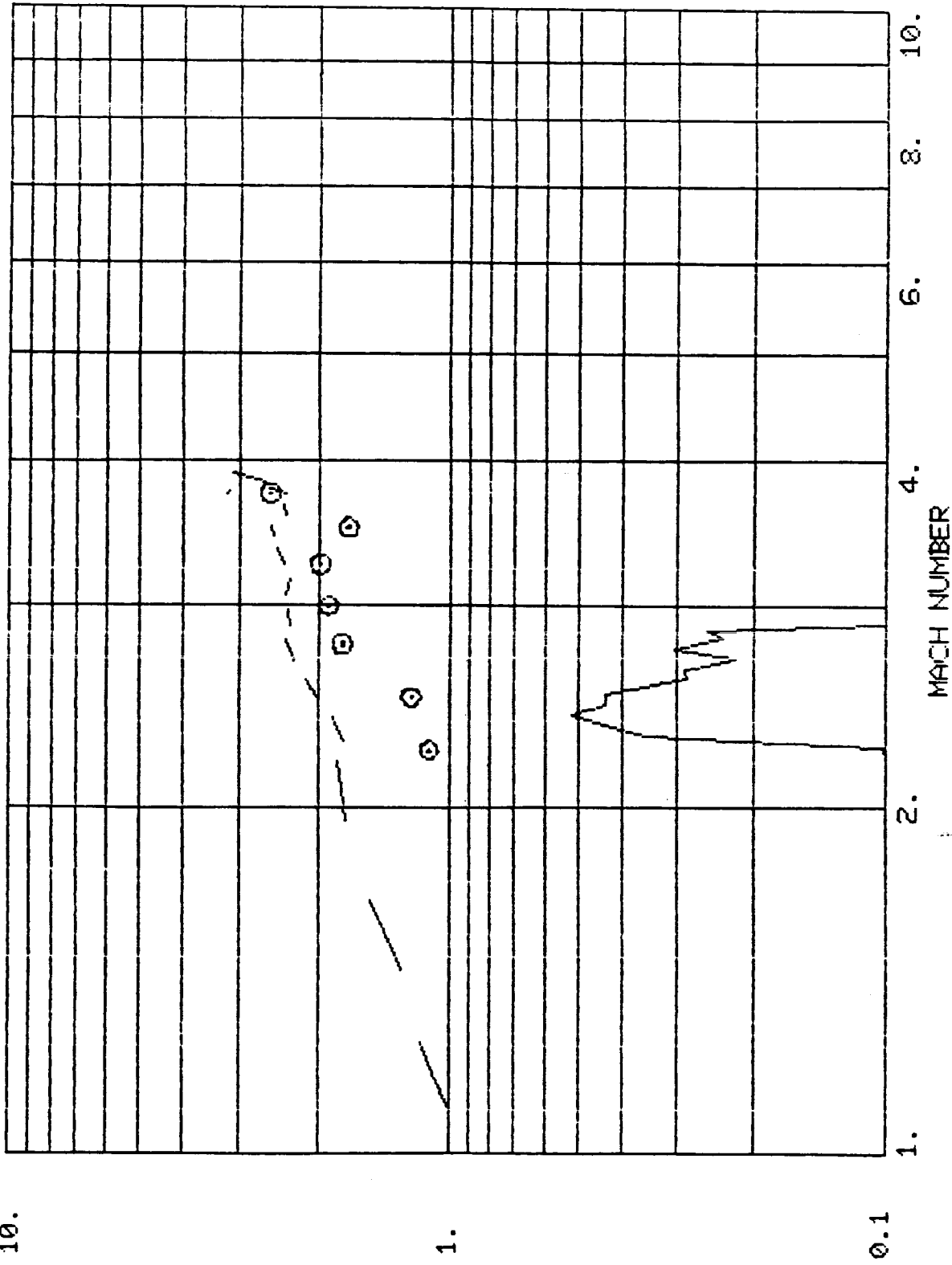


Fig. 3.20

NOTE: Bad Flight Data

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9028, ISLAND 35 10.

H_I / H_D 1.

0.1

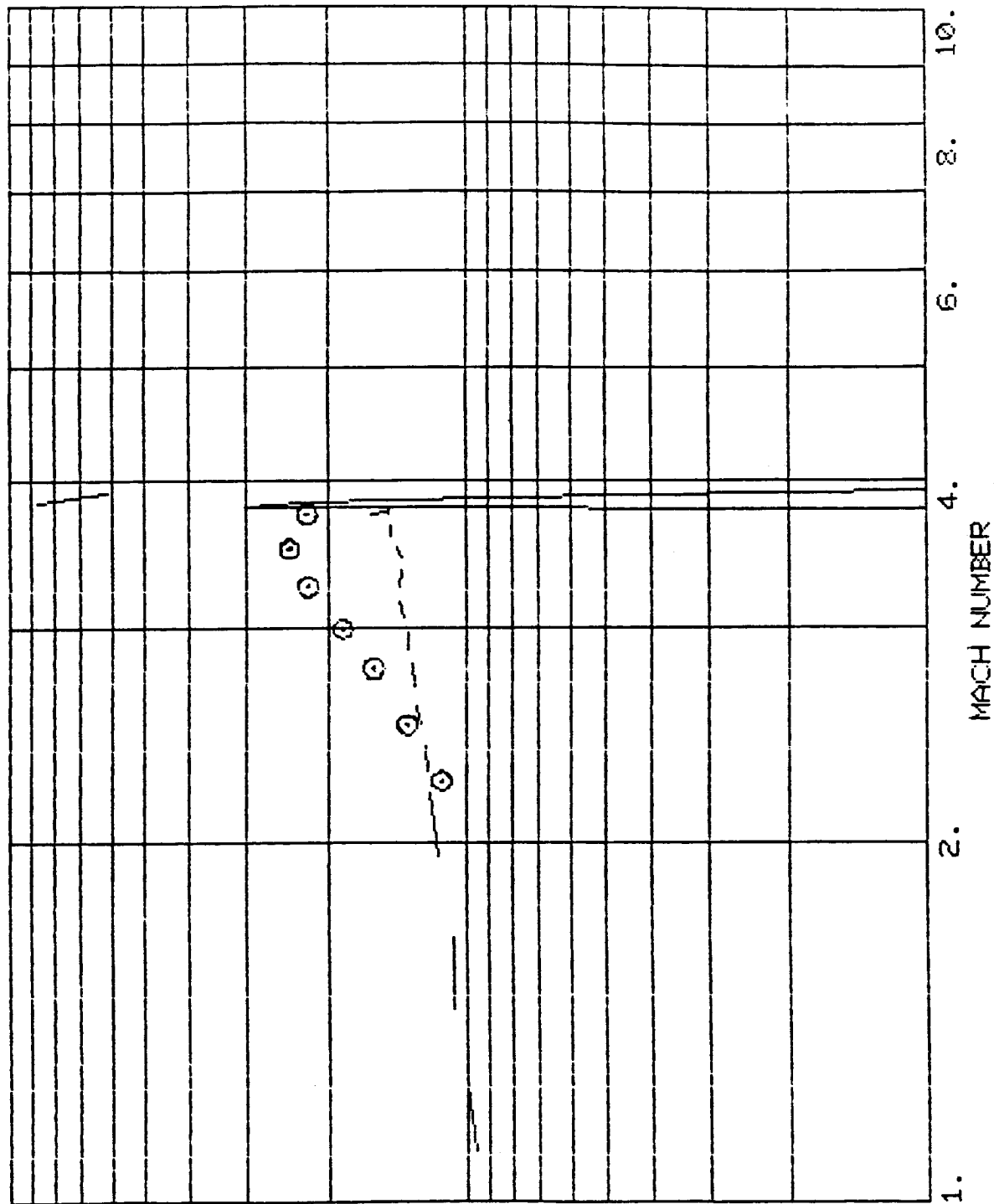


Fig. 3.21

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9029, ISLAND 32
10.

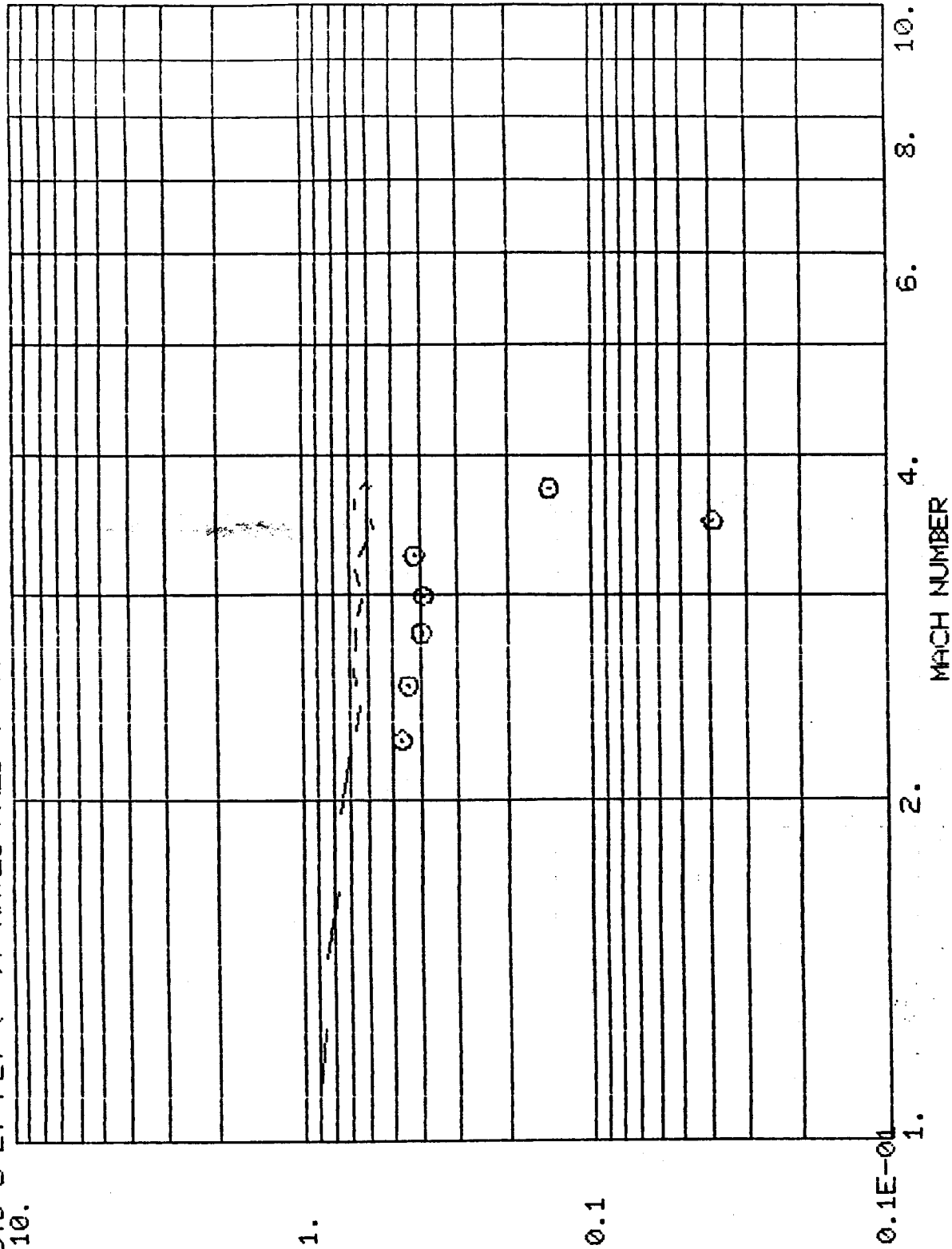


Fig. 3.22

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9030, ISLAND 34
10.

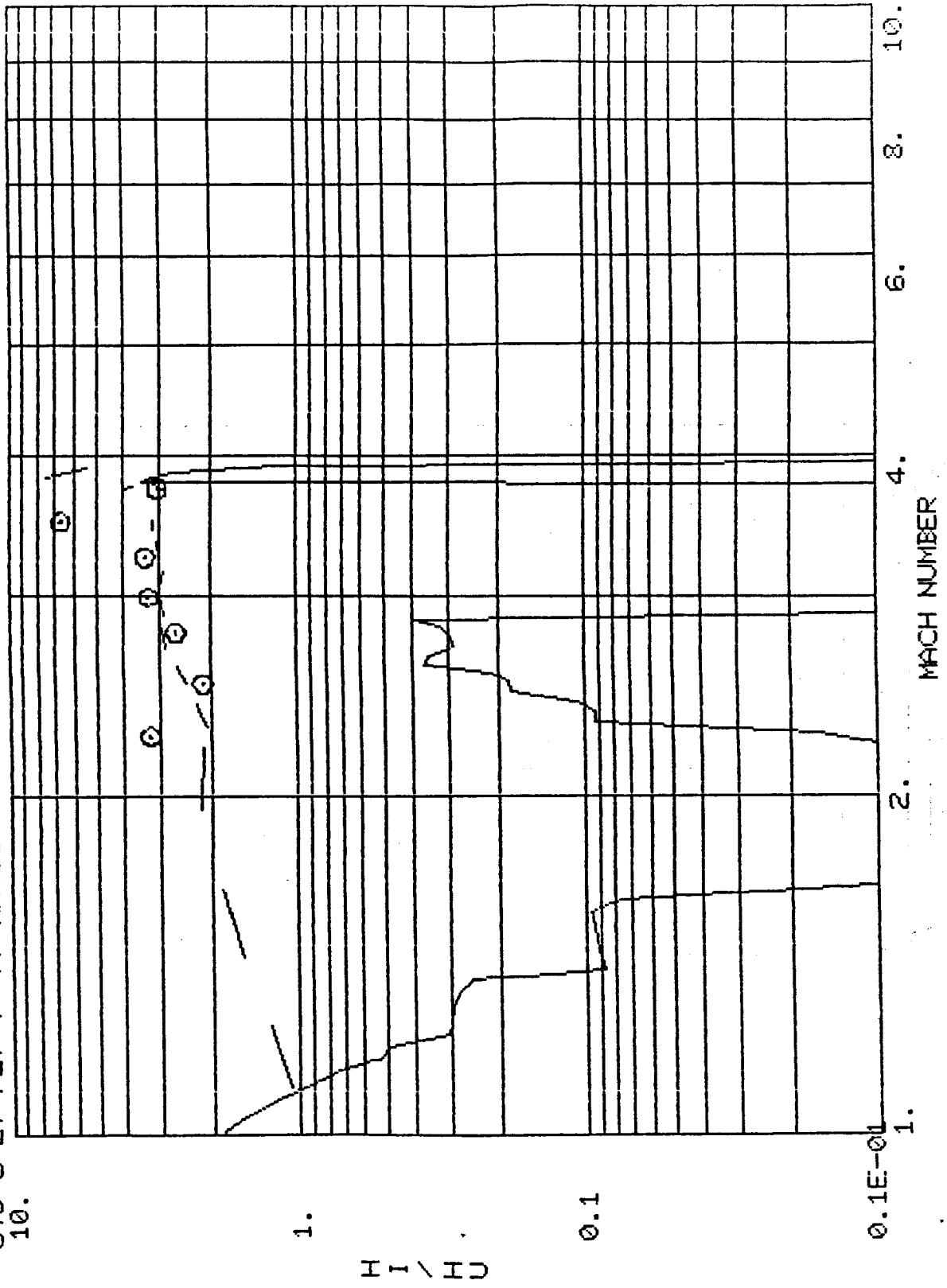


Fig. 3.23

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9031, ISLAND 35
10.

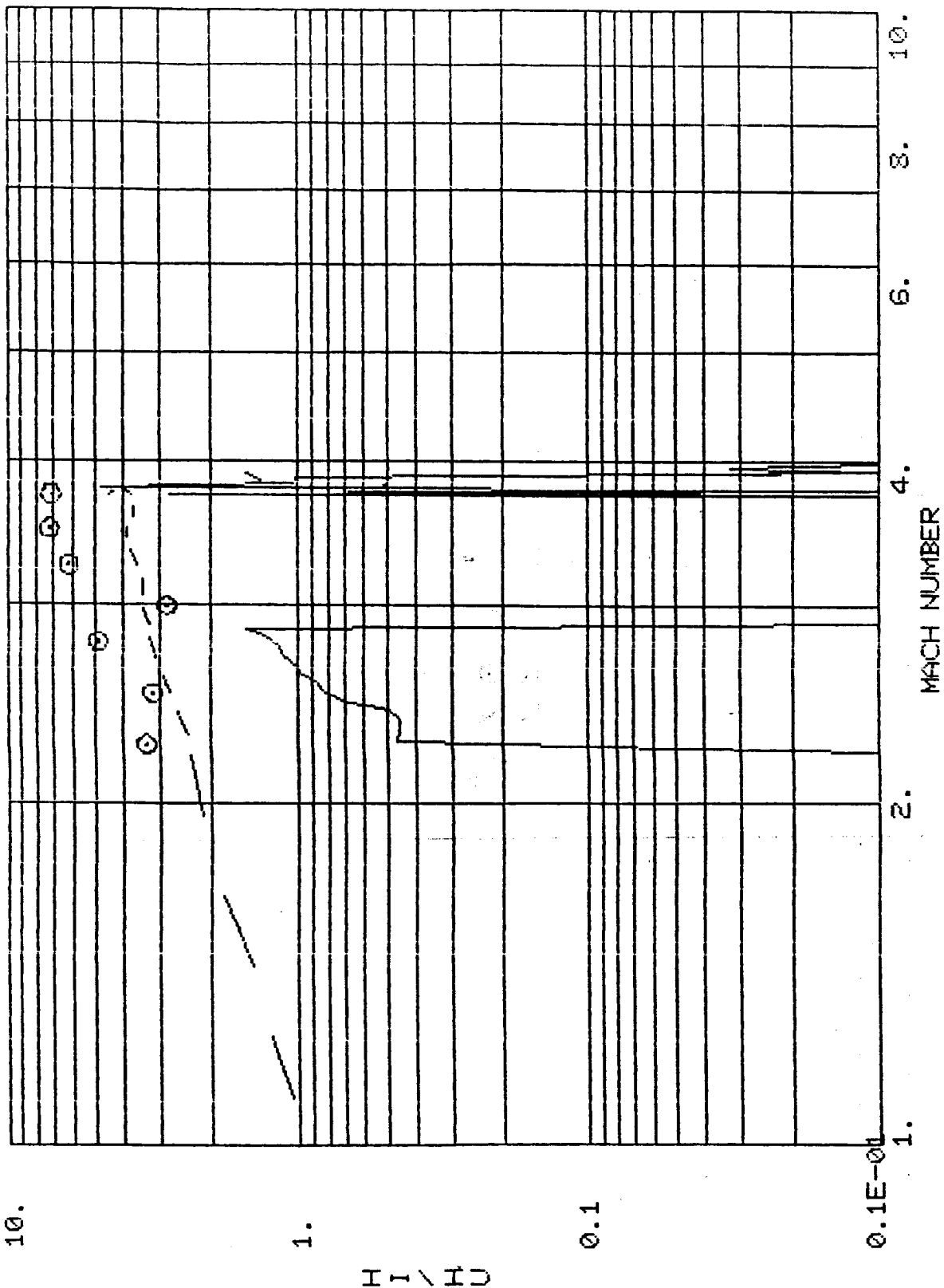


Fig. 3.24

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9032, ISLAND 37
10.

H I \ H D

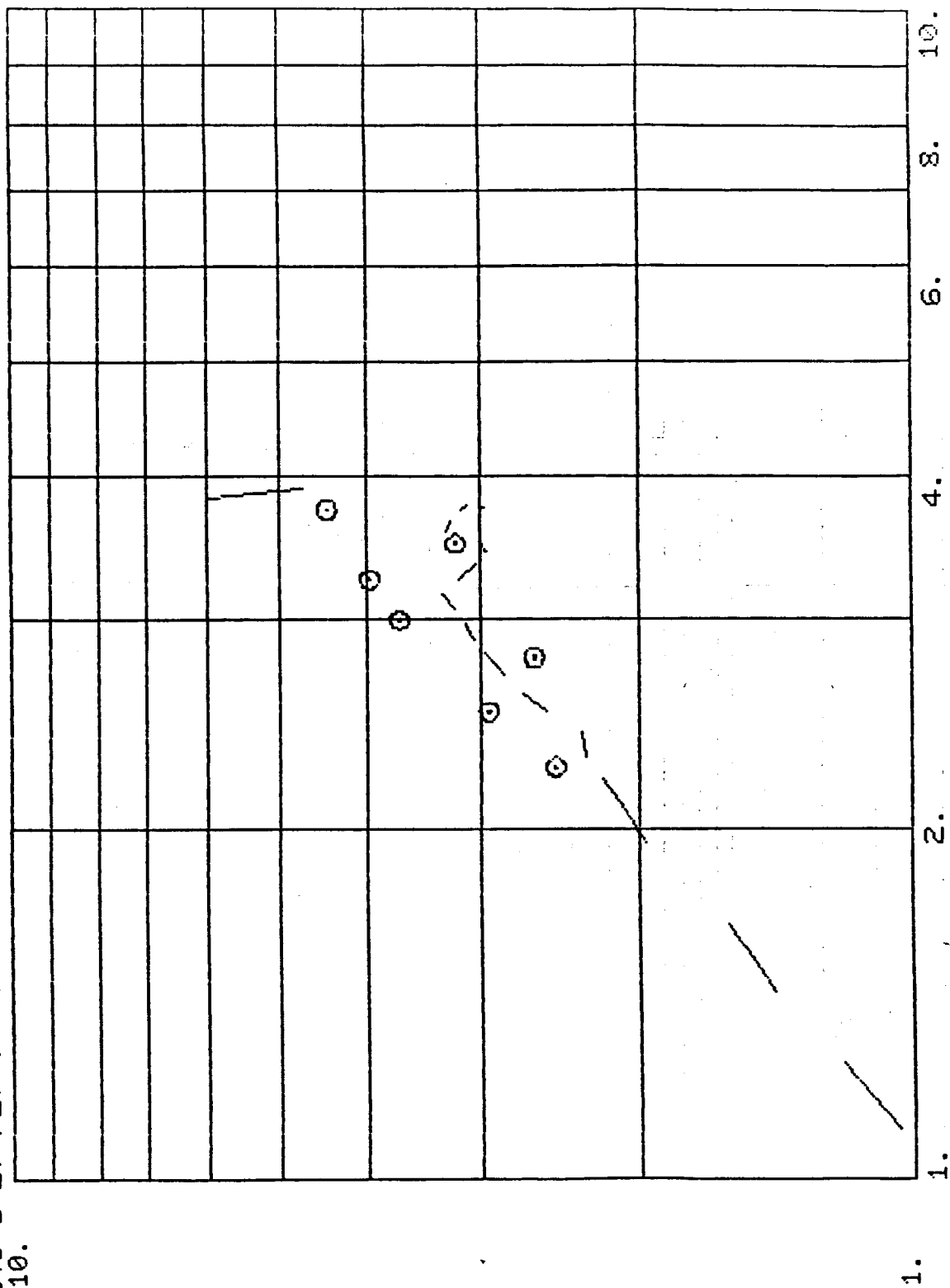


Fig. 3.25

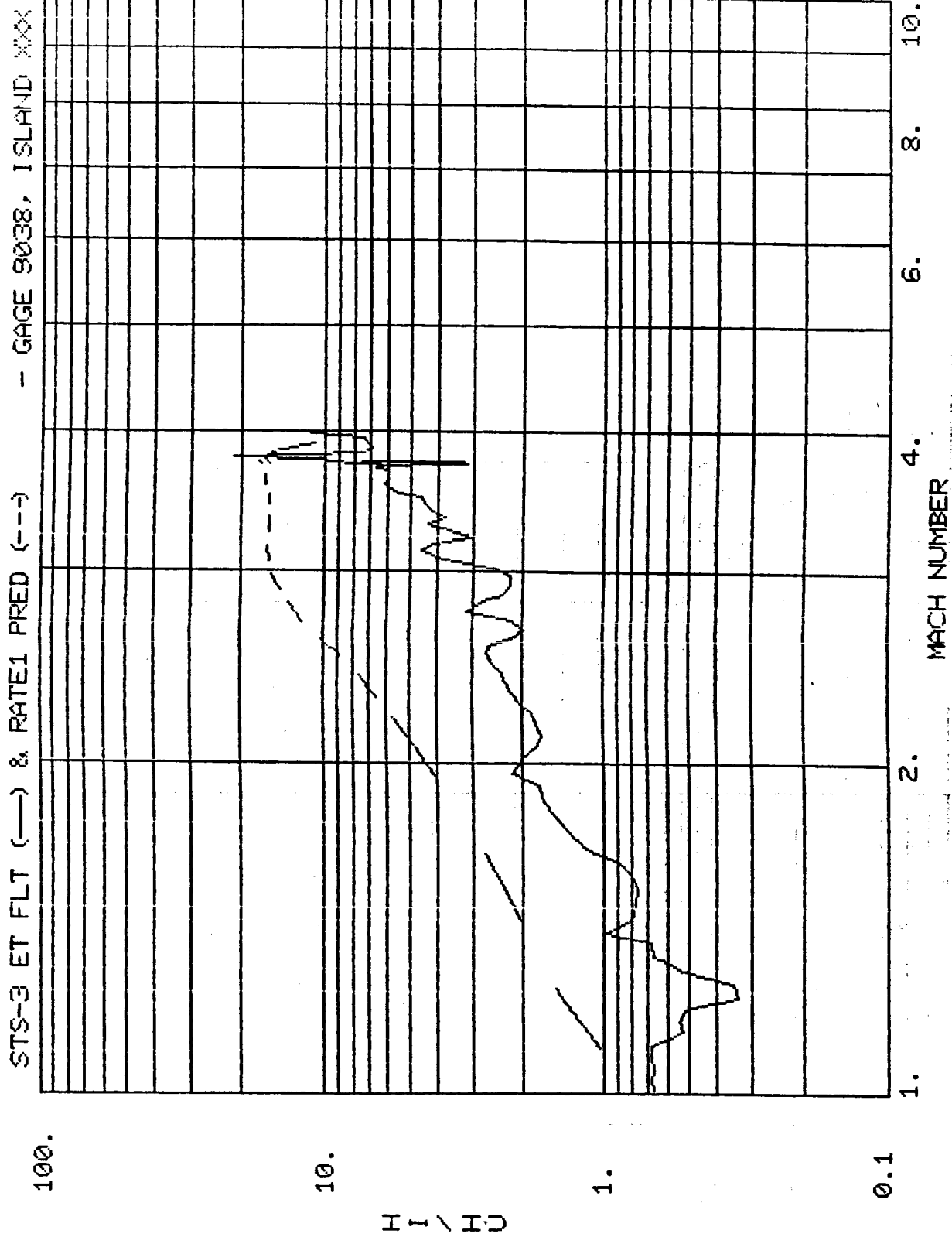


Fig. 3.26

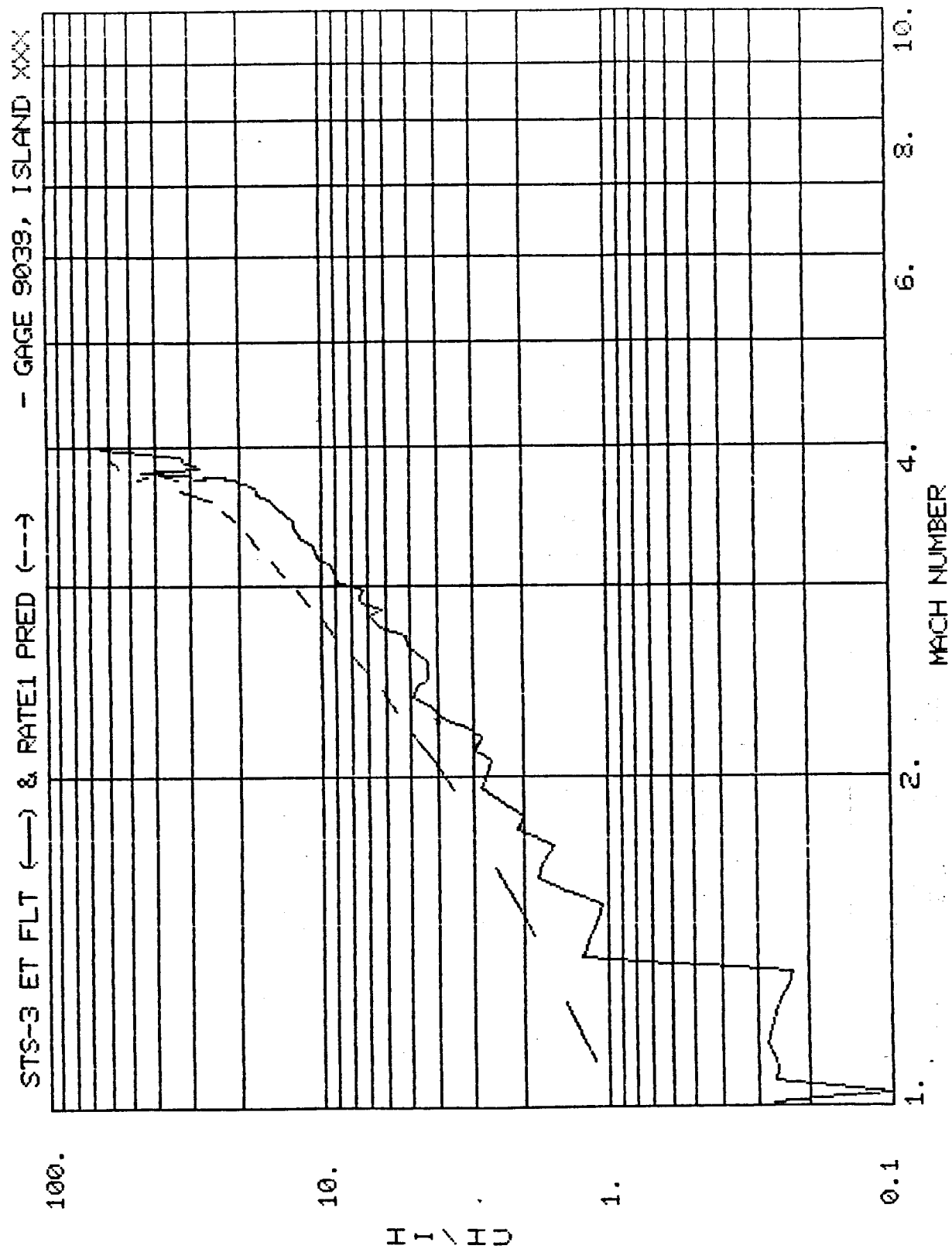


Fig. 3.27

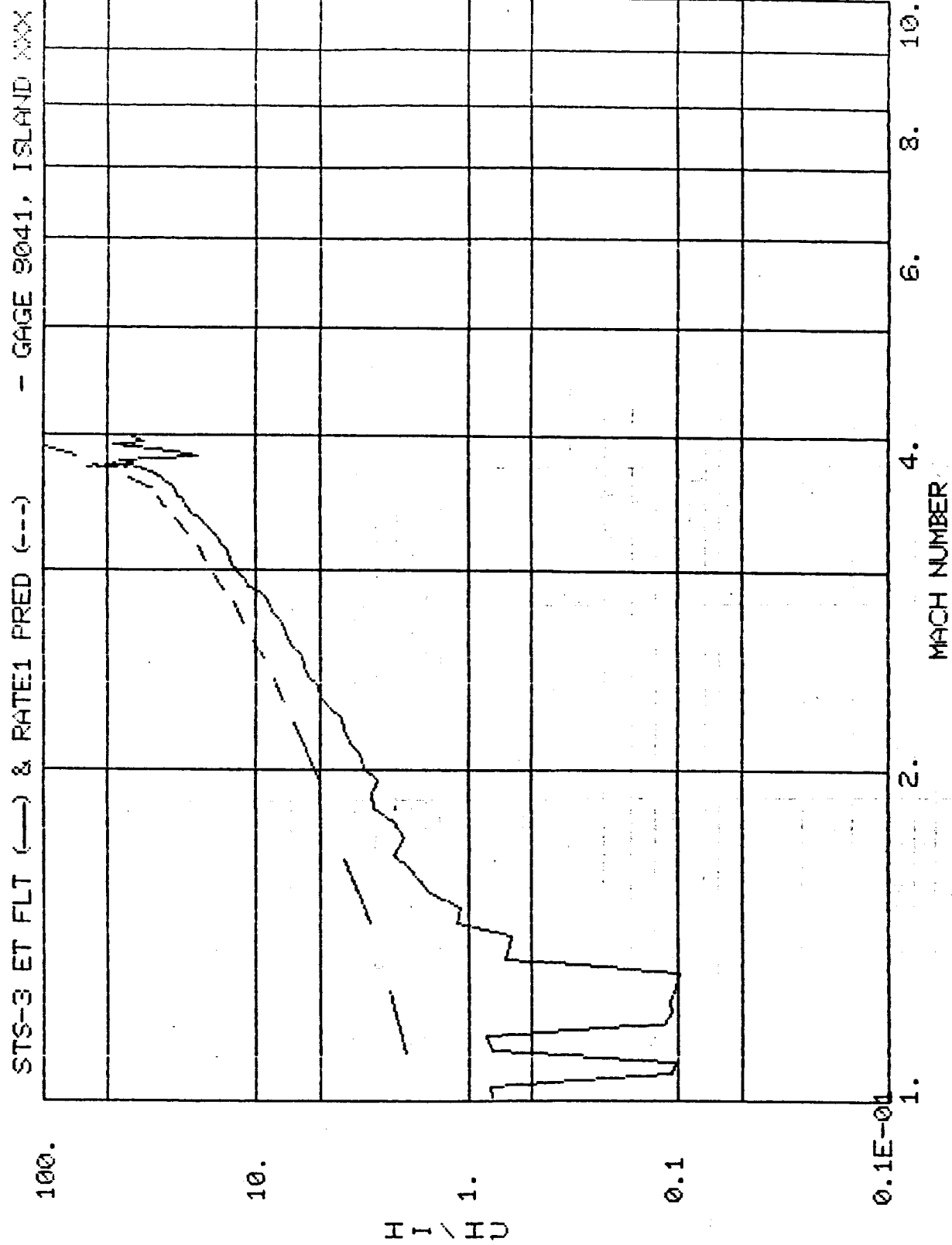


Fig. 3.28

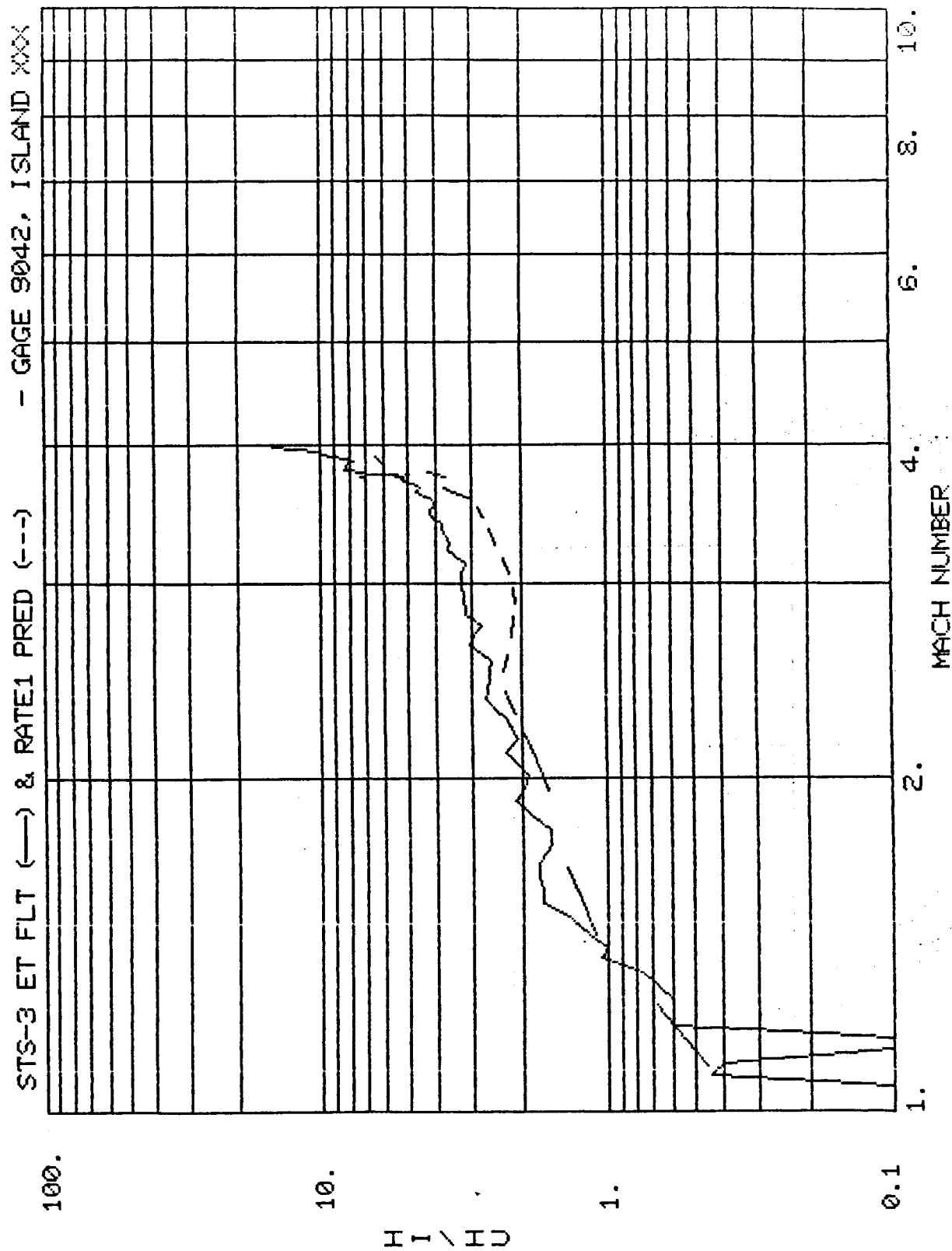


Fig. 3.29

STS-3 ET FLT (—) & RATE1 PRED (---) - GAGE 8045, ISLAND XXX

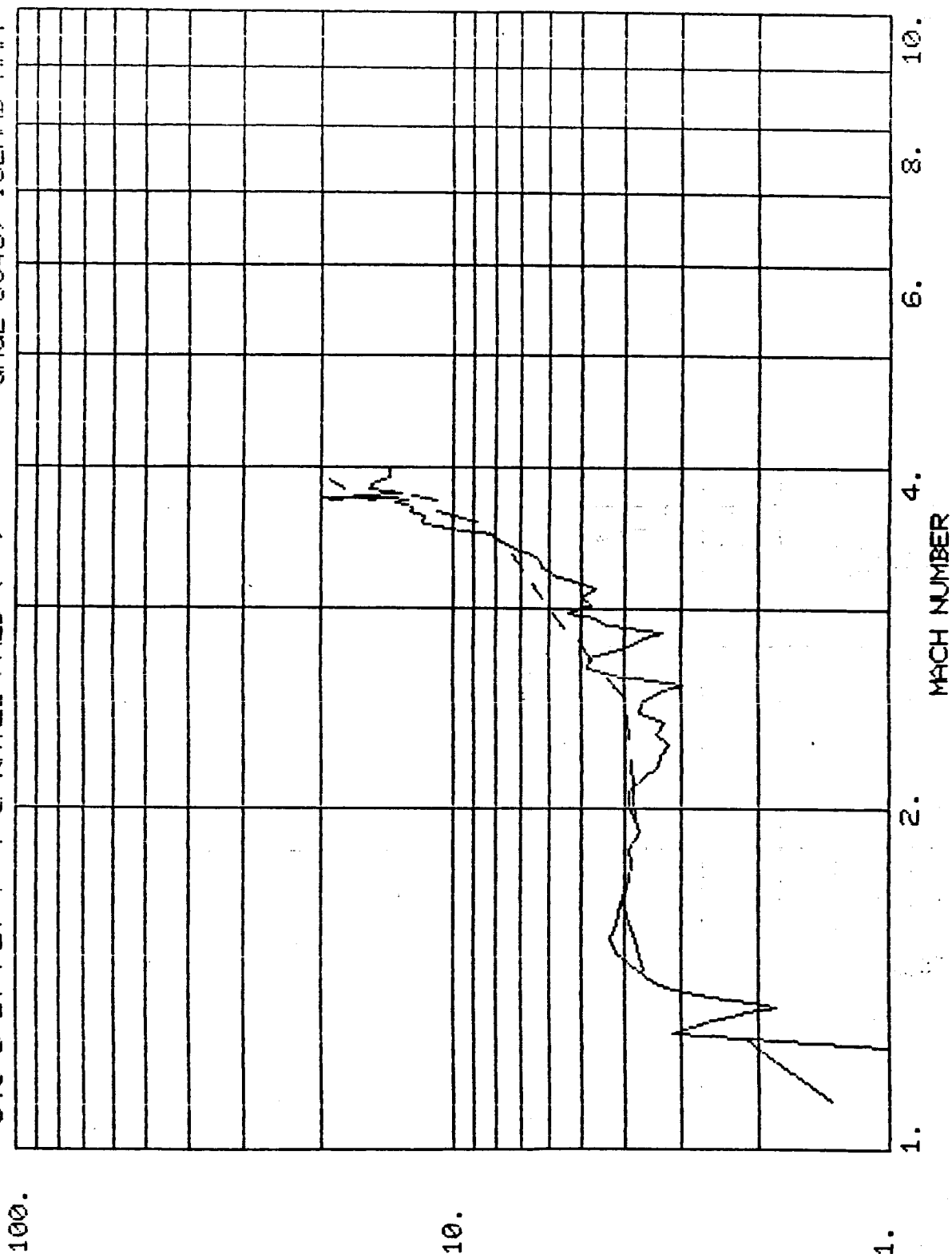


Fig. 3.30

STS-3 ET FLT (—) & RATE1 PRED (---) - GAGE 9046, ISLAND XXX

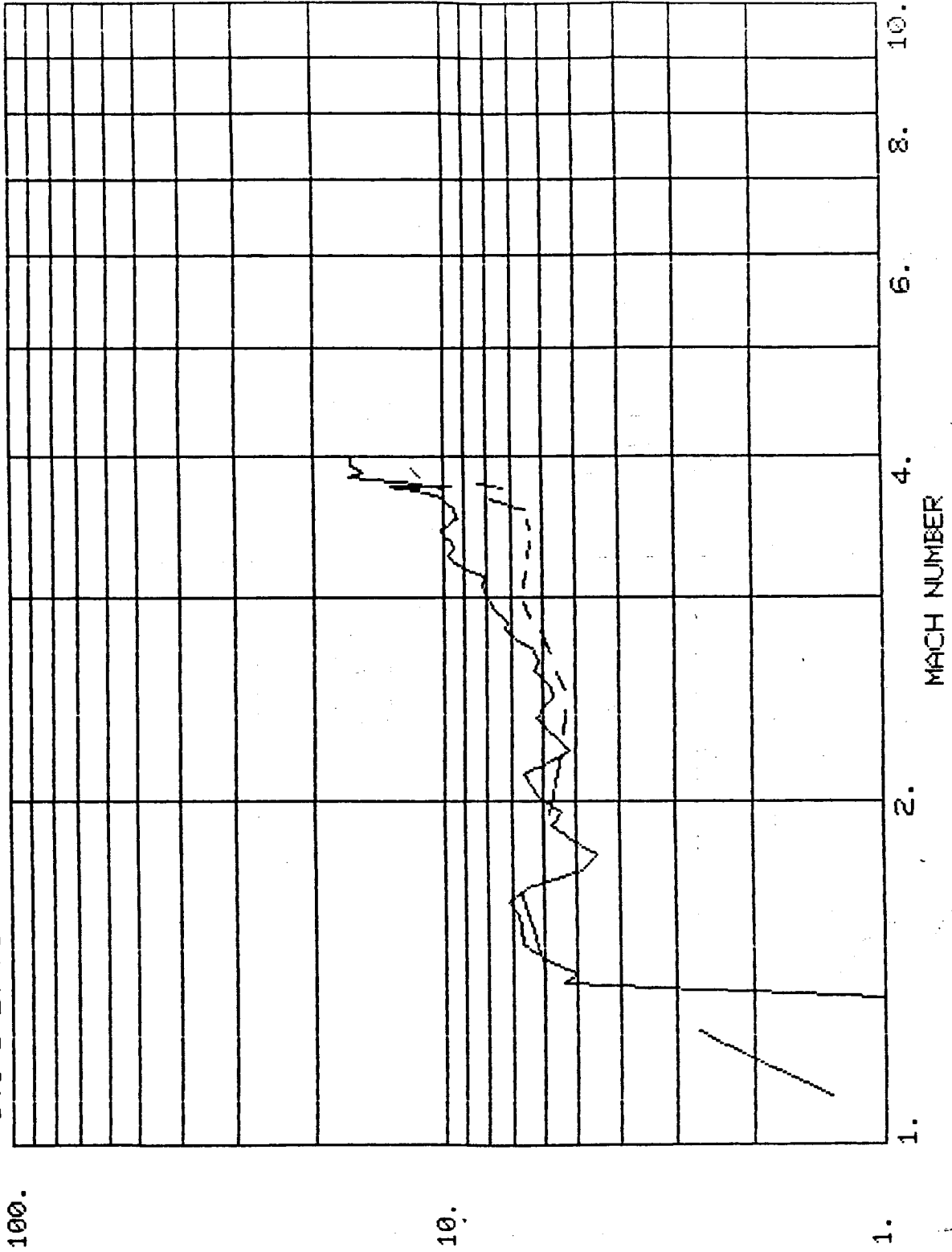


Fig. 3.31

C-2

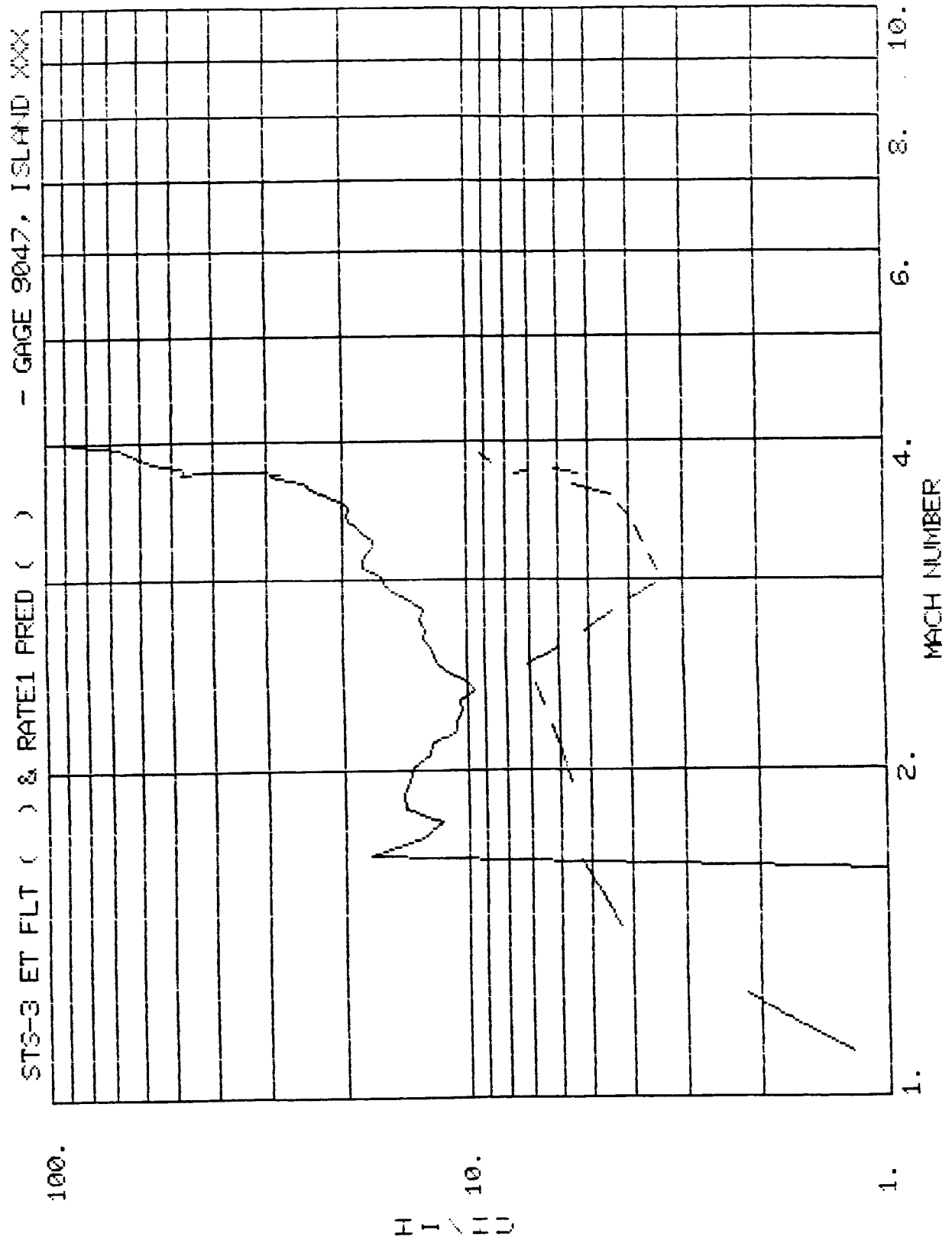


Fig. 3.32

REMTECH INC.

SET 4

STS-4 pp. 4.1 - 4.36

REMTECH INC.

Table 4.1 STS-4 DFI LOCATIONS

MEASUREMENT I.D.	XT (IN.)	THETA (DEG.)	GAGE TYPE	LOCATION
T07R9001A	350.0	180.0	Ind. Gage	40° Cone
T07R9004A	467.4	264.0	Island 2	L02 Tank
T07R9005A	467.4	174.0	Island 1	L02 Tank
T07R9007A	672.5	270.0	Island 6	L02 Tank
T07R9008A	672.5	180.0	Island 5	L02 Tank
T07R9010A	825.5	270.0	Island 8	L02 Tank
T07R9011A	976.0	25.0	Island 18	Intertank
T07R9012A	1008.0	21.0	Ind. Gage	L02 Fdln. Fairing (side)
T07R9013A	1110.4	2.5	Island 17(3)	Intertank
T07R9014A	937.4	288.6	Island 16	Intertank
T07R9015A	956.2	270.0	Island 15	Intertank
T07R9016A	937.4	251.4	Island 14	Intertank
T07R9017A	948.5	180.0	Island 12	Intertank
T07R9018A	1098.5	2.5	Island 17(2)	Intertank
T07R9019A	1084.4	2.5	Island 17(1)	Intertank
T07R9020A	1147.4	358.0	Island 27	LH2 Barrel
T07R9021A	1030.1	270.0	Island 20	Intertank
T07R9022A	1073.8	180.0	Island 23	Intertank
T07R9023A	1130.3	0.0	Island 26	LH2 Barrel
T07R9025A	1489.0	264.4	Island 29	LH2 Barrel
T07R9026A	1489.0	172.5	Island 28	LH2 Barrel
T07R9027A	2017.0	5.6	Island 33	LH2 Barrel
T07R9028A	2057.0	5.6	Island 35	LH2 Barrel
T07R9029A	2002.5	168.7	Island 32	LH2 Barrel
T07R9030A	2038.97	356.3	Island 34	LH2 Barrel
T07R9031A	2057.0	276.0	Island 36	LH2 Barrel
T07R9032A	2057.0	340.6	Island 37	LH2 Barrel
T07R9038A	996.0	23.0	Ind. Gage	L02 Fdln Fairing (top)
T07R9039A	1129.9	356.0	Ind. Gage	ET/ORB Fwd LH Strut
T07R9041A	959.2	270.0	Ind. Gage	Bolt Catcher
T07R9042A	2002.0	29.0	Ind. Gage	RH Thrust Strut
T07R9045A	2058.0	10.0	Ind. Gage	Aft Diag. Strut
T07R9046A	2100.0	45.0	Ind. Gage	LH Vert Strut Cable Tray
T07R9047A	2035.0	26.0	Ind. Gage	Fwd. L02 Fdln/X-Beam Cable Tray

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Table 4.2 STS-4 ET INTERFERENCE FACTORS FROM THE IH-97A WIND TUNNEL DATA BASE

GAGE ! IH97A		HI/HU @ MACH NUMBER							
NO. !	NO. !	2.25 !	2.50 !	2.75 !	3.00 !	3.25 !	3.50 !	3.75 !	4.00
9001	5029	0.781	0.964	1.088	1.801	1.349	0.703	0.269	0.196
9004	5031	1.016	0.967	0.962	1.023	0.971	0.975	0.906	0.952
9005	5030	0.947	0.939	0.930	0.946	0.946	0.968	0.882	0.942
9007	5033	0.919	0.906	0.891	1.029	0.908	0.940	0.794	0.946
9008	5032	1.133	1.130	1.120	1.182	1.074	1.116	1.050	1.062
9010	5034	0.390	0.507	0.460	0.420	0.419	0.309	0.276	0.302
9011	5042	1.408	1.274	0.941	0.793	1.489	—	1.355	1.385
9013	5041	—	—	—	3.892	3.415	3.565	4.863	—
9014	5038	3.657	3.373	4.203	4.650	5.523	6.081	6.264	7.202
9015	5258	5.590	7.321	8.232	8.679	9.210	9.216	12.669	13.006
9016	5036	3.954	4.155	4.021	4.444	4.878	5.684	5.689	5.873
9017	5035	0.655	0.650	0.709	0.773	0.844	0.752	0.819	0.863
9018	5039	2.992	3.585	3.557	3.383	3.221	3.395	3.114	3.628
9019	5040	2.606	3.124	2.790	2.554	2.342	2.414	2.084	2.593
9020	5250	2.751	3.122	3.716	4.739	5.069	5.845	6.042	5.830
9021	5043	0.204	0.395	0.505	0.686	1.015	—	1.409	1.403
9022	5044	1.534	1.232	0.955	0.709	0.778	0.738	0.784	0.886
9023	5249	3.109	3.485	3.883	3.692	4.234	3.101	3.914	3.493
9024	5251	1.104	1.243	1.392	1.663	1.875	1.972	2.005	2.032
9025	5046	—	1.073	0.859	0.770	0.770	0.409	0.377	0.436
9026	5045	0.683	0.879	0.866	0.883	0.799	0.901	0.725	0.780
9027	5048	1.093	1.367	1.445	1.627	1.973	2.992	1.282	0.911
9028	5050	1.082	1.279	1.395	1.802	2.421	2.338	2.626	2.347
9029	5047	—	0.500	0.460	0.539	0.213	0.213	0.016	0.276
9030	5049	1.967	1.816	2.618	2.992	2.594	4.222	4.060	2.194
9031	5051	3.826	3.378	5.073	5.471	6.129	4.188	3.453	7.661
9032	5052	2.327	2.799	3.008	3.107	3.050	3.408	2.609	4.887
9033	5252	1.400	1.133	1.601	1.340	1.503	1.480	0.997	0.996

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9001, ISLAND XXX
10.

HI \ HD
1.

0.1

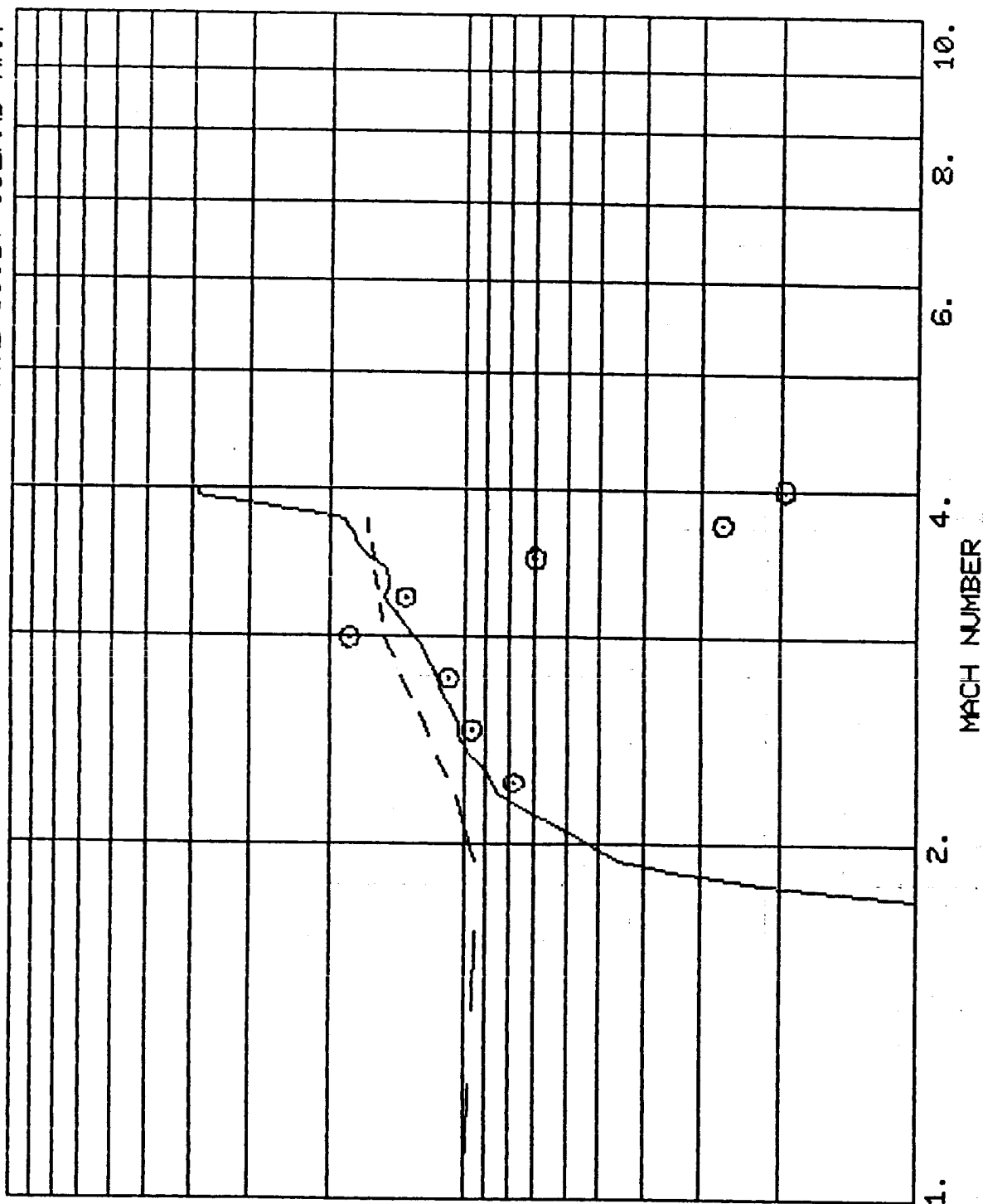


Fig. 4.1

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9004, ISLAND 2

H I / H U 1.

0.1

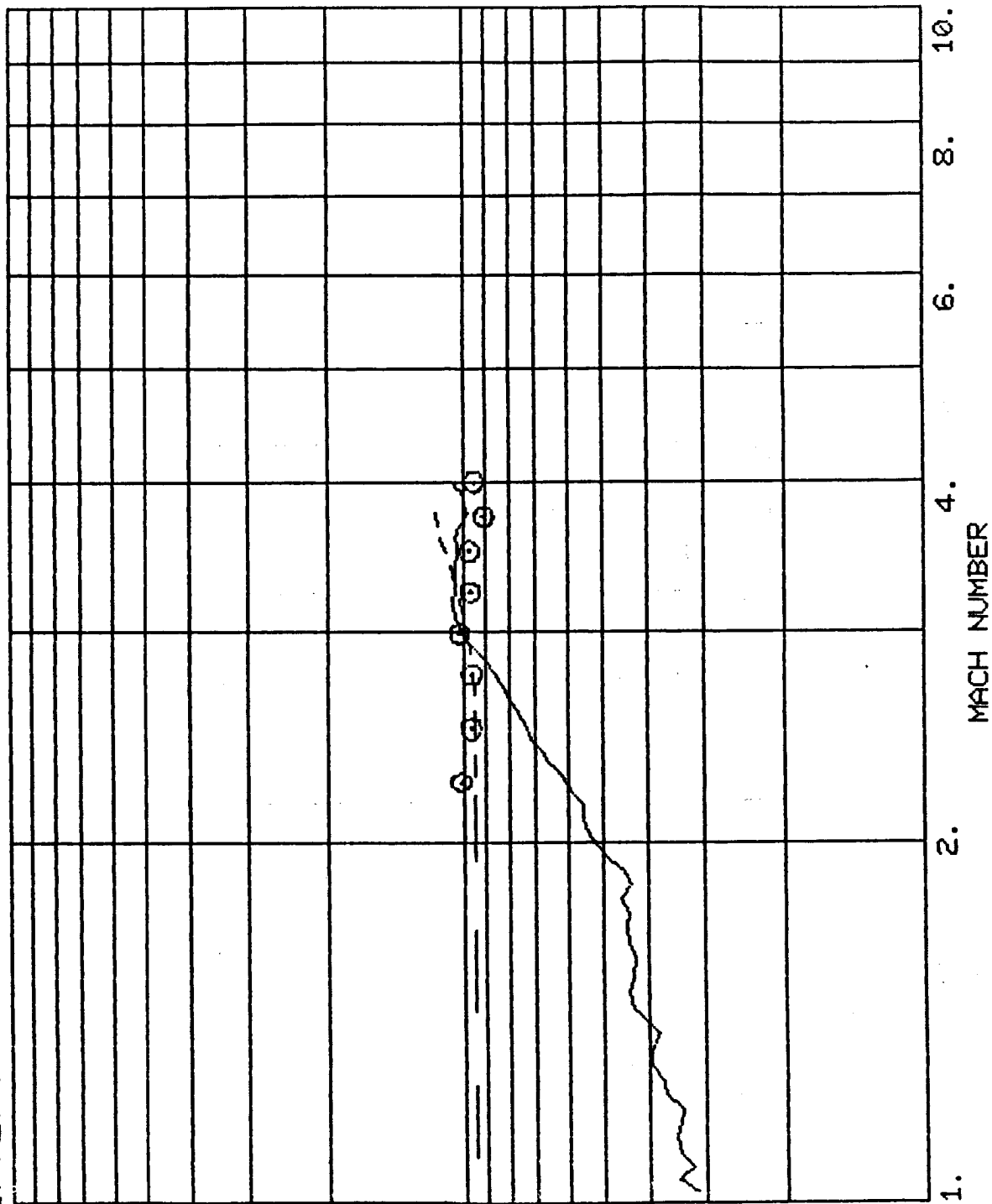


Fig. 4.2

STS-4 ET FLT (—), RATE1 PRED (---), & IH87-A (O) - GAGE 9005, ISLAND 1

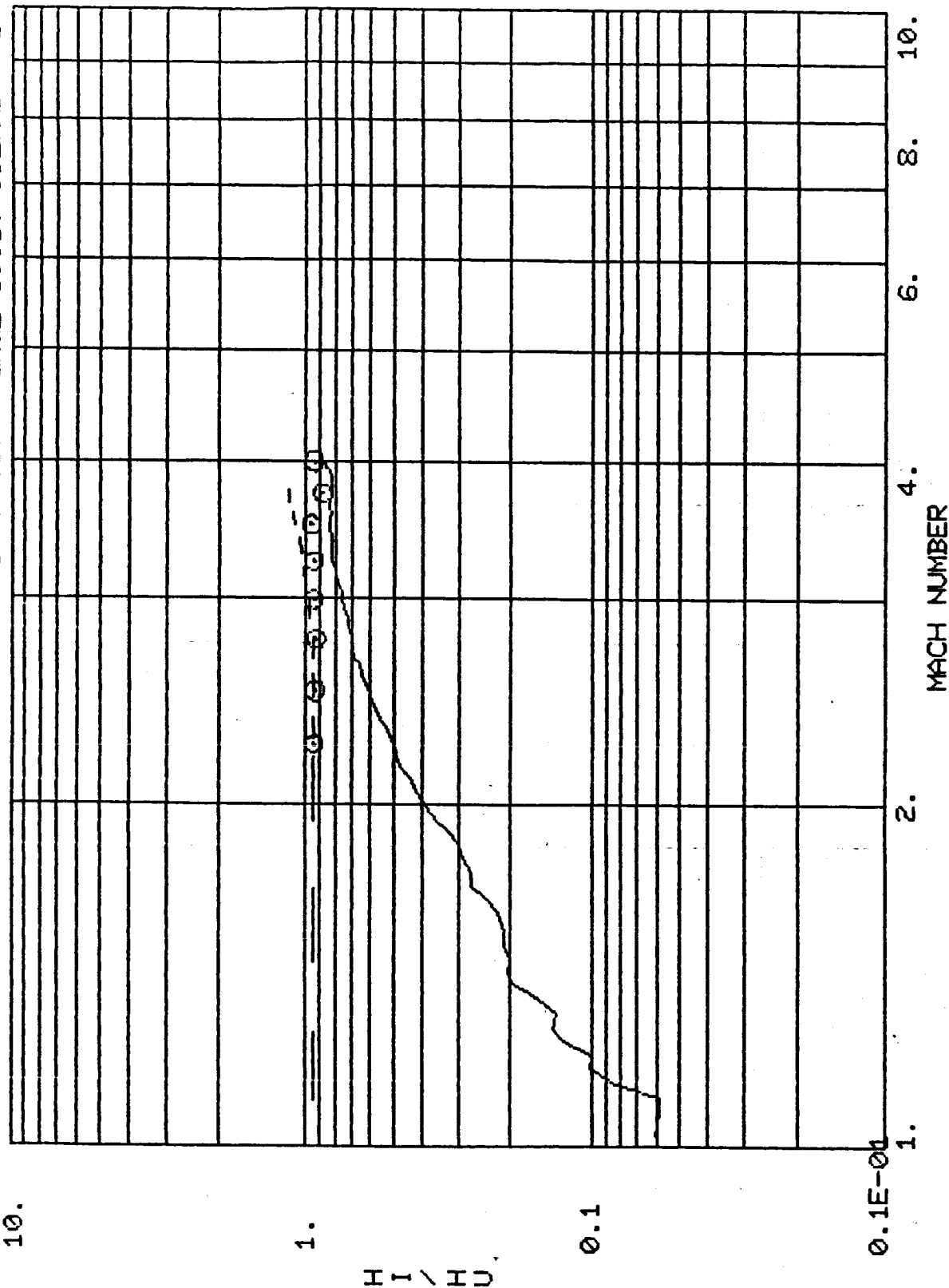


Fig. 4.3

STS-4 ET FLT (—), RATE1 FRED (---), & IH97-A (O) - GAGE 9007, ISLAND 6

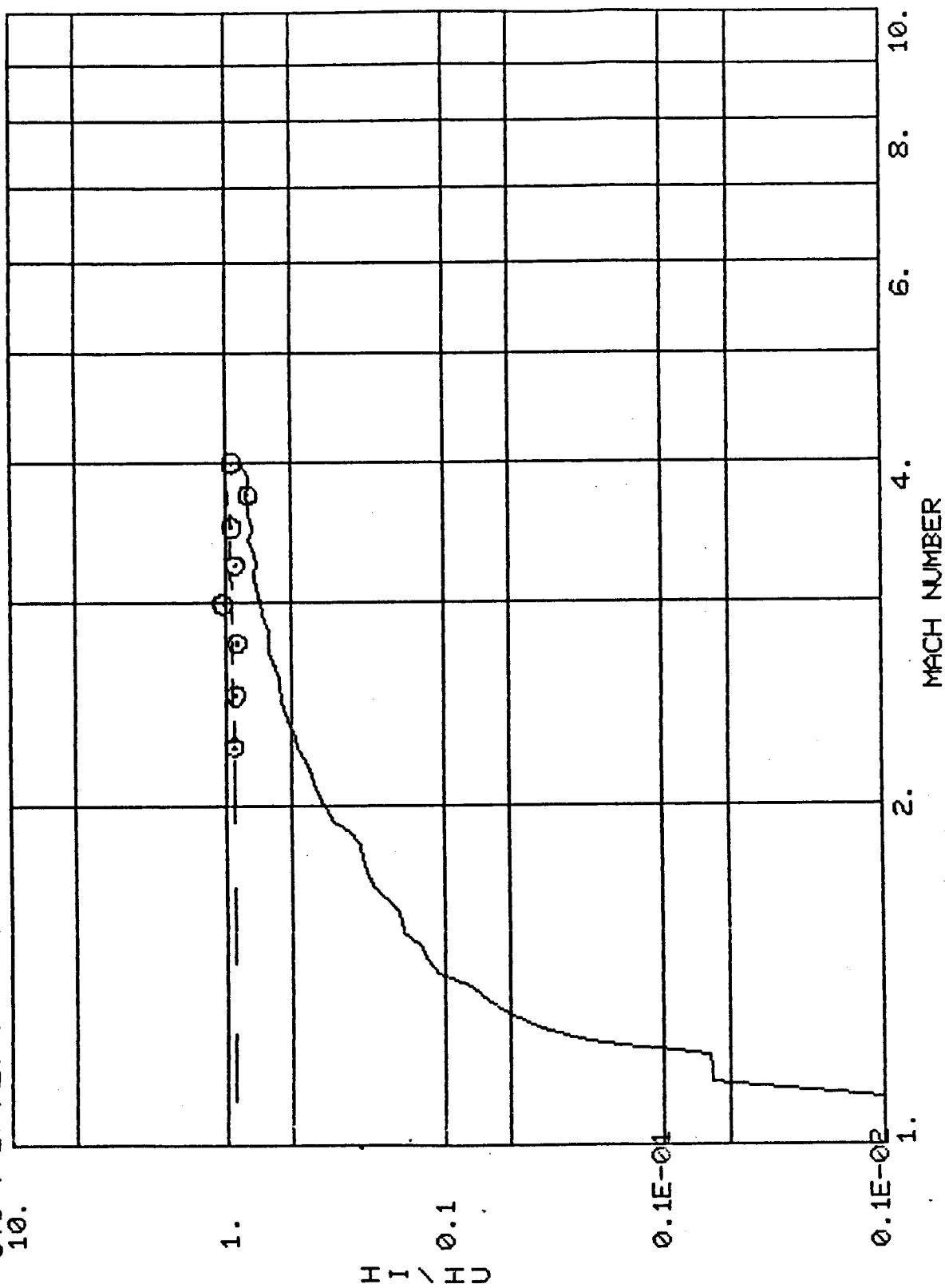


Fig. 4.4

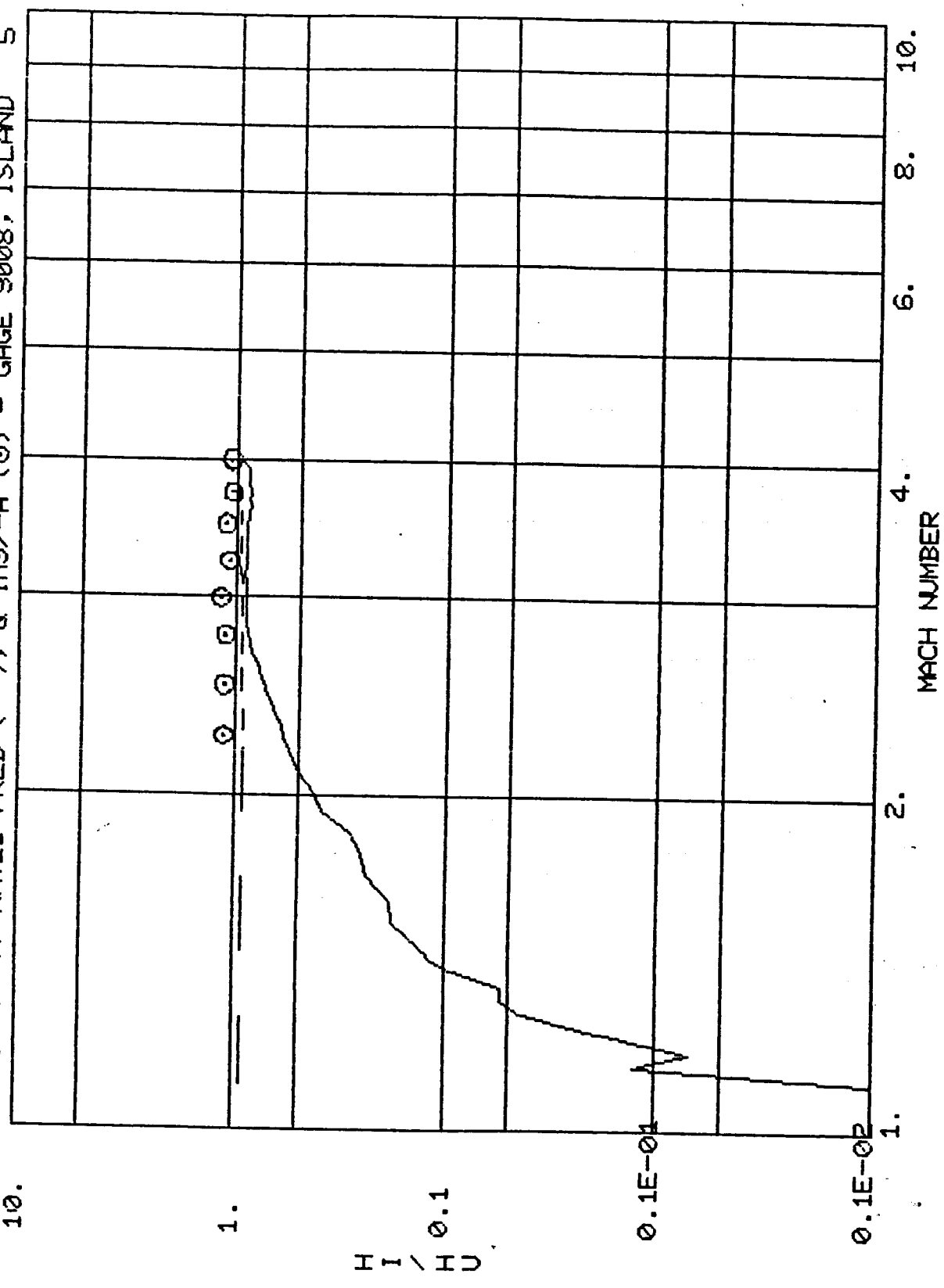


Fig. 4.5

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9010, ISLAND 8

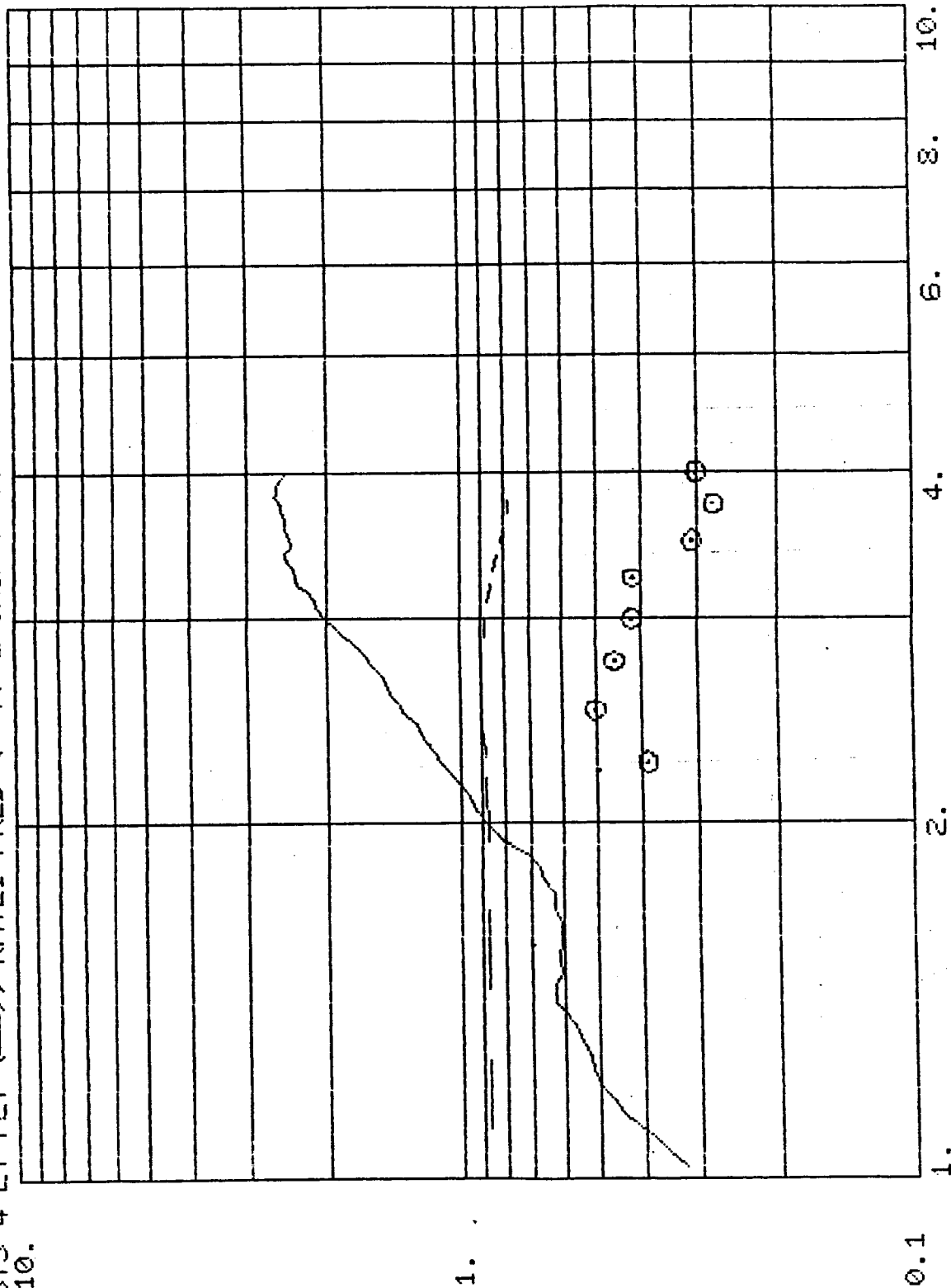


Fig. 4.6

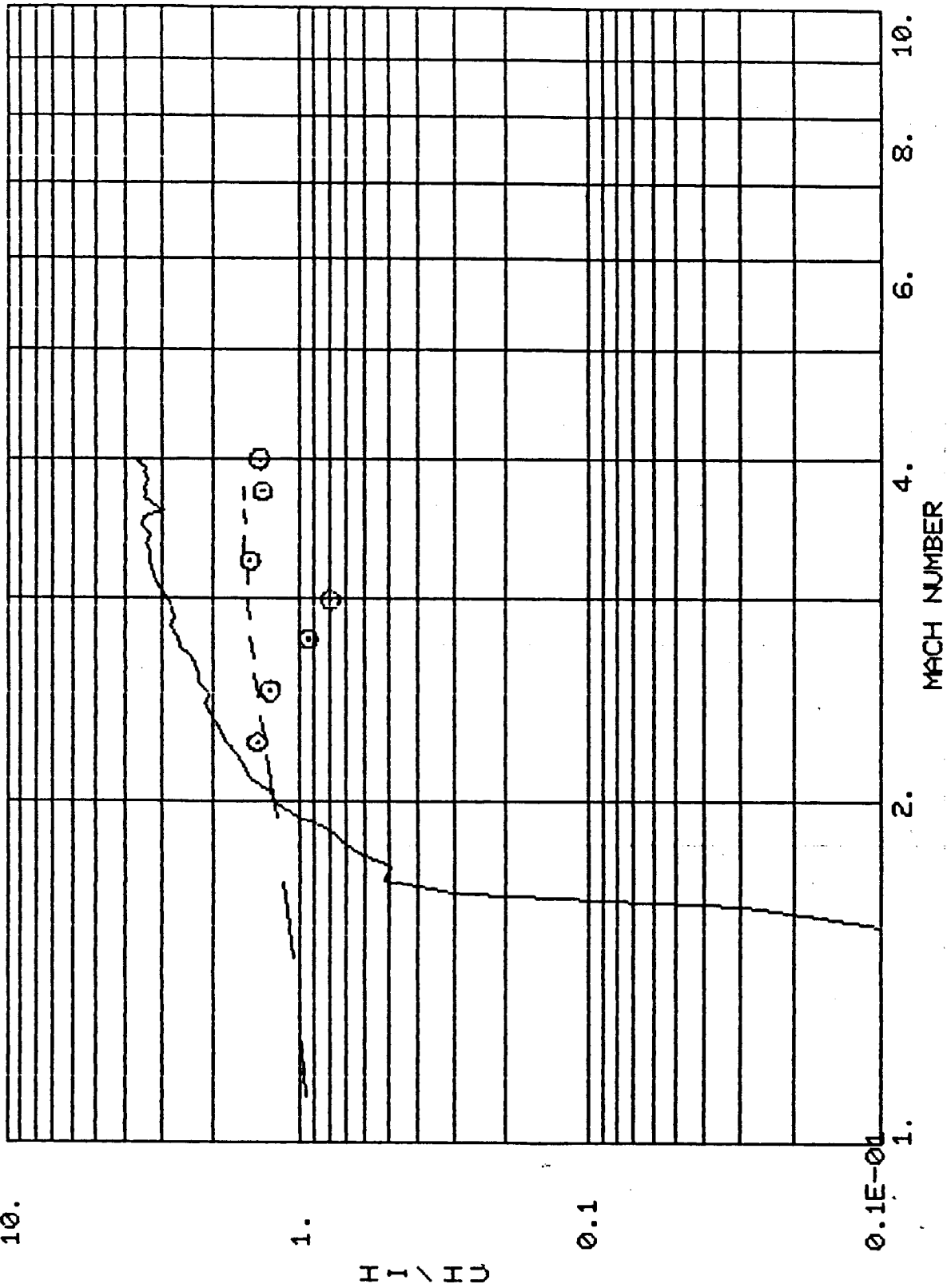


Fig. 4.7

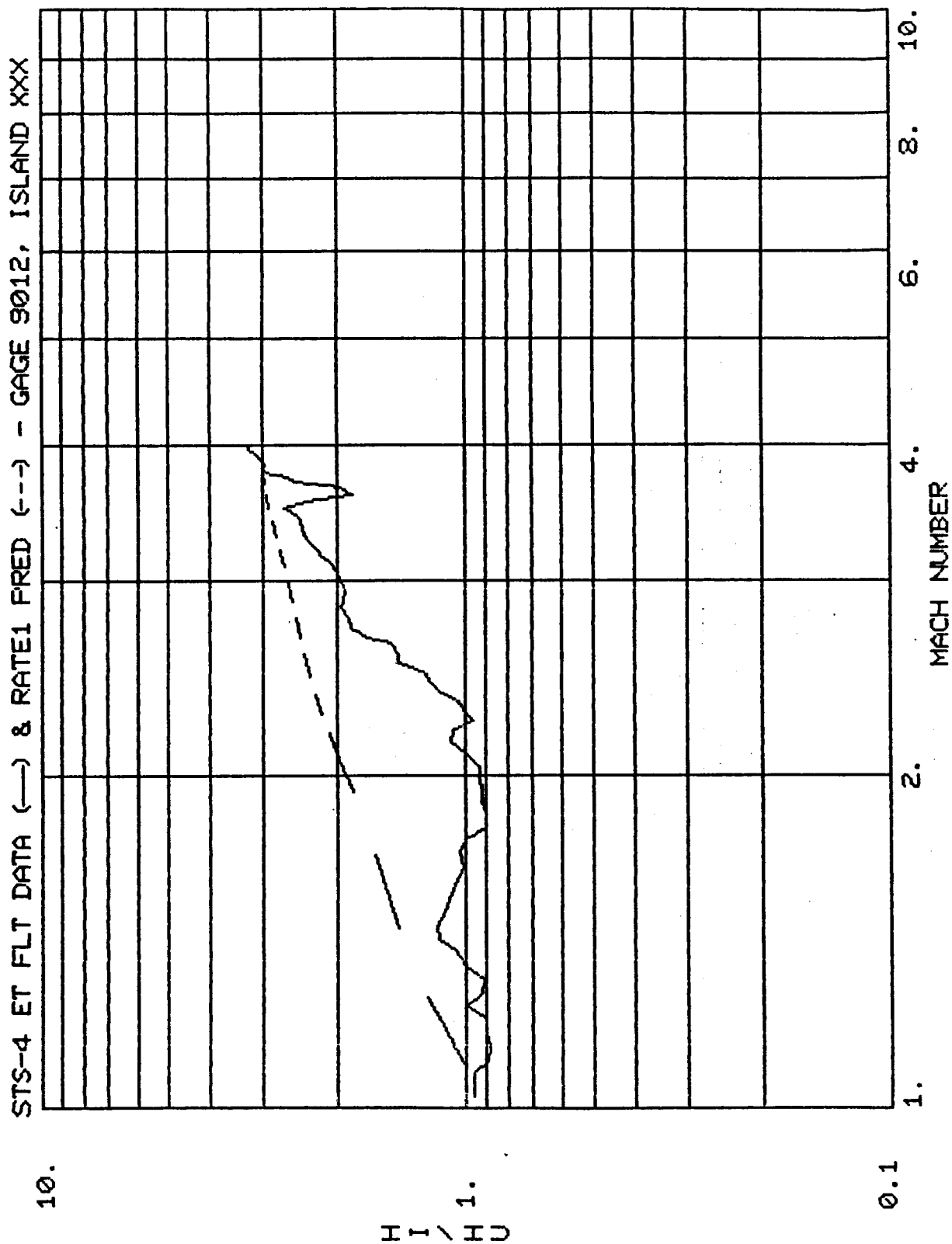


Fig. 4.8

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9013, ISLAND 173
10.

H I \ H D

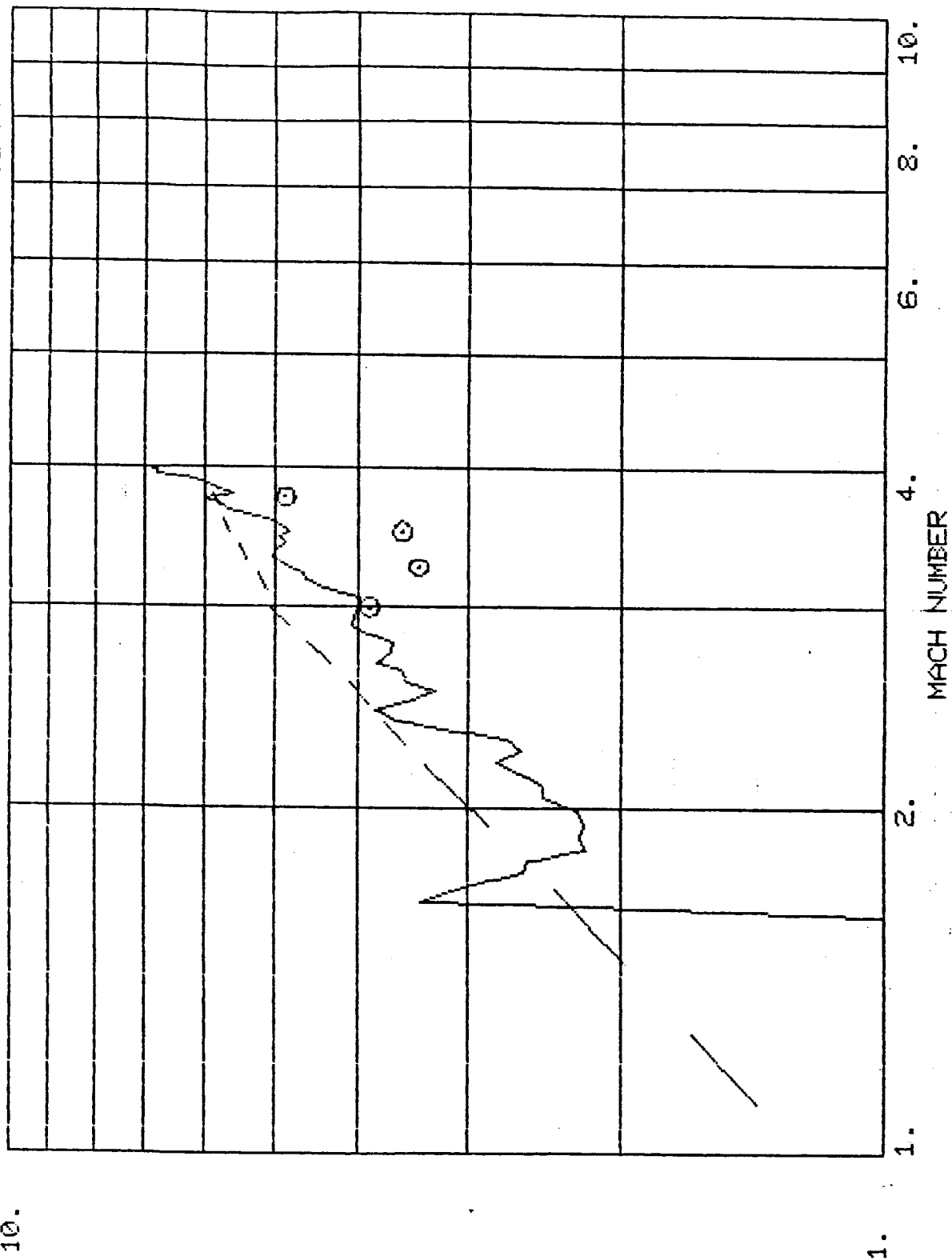


Fig. 4.9

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9014, ISLAND 16

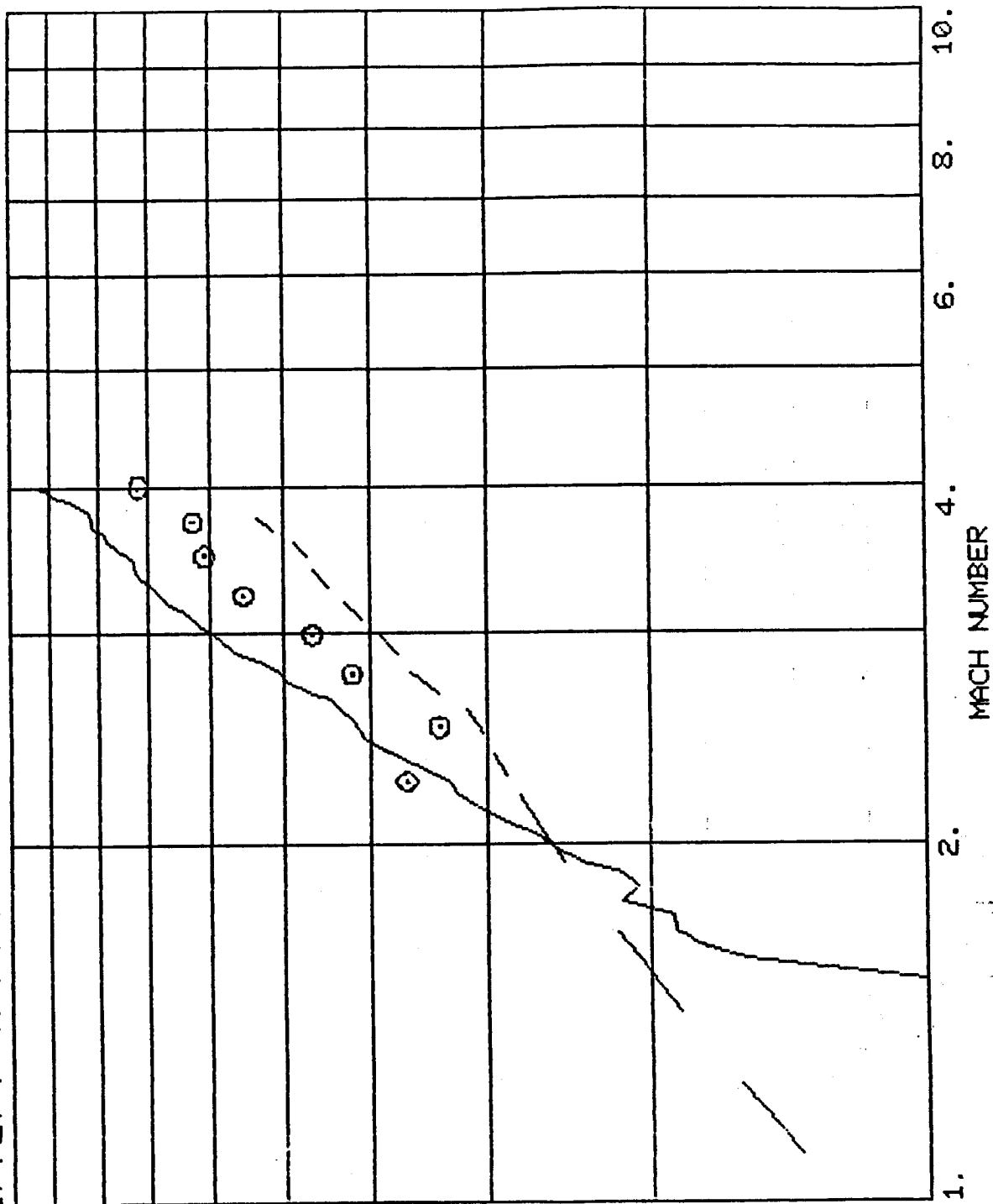


Fig. 4.10

STS-4 ET FLT (—), RATE1 PRED (---), & IH37-A (O) - GAGE 9015, ISLAND 15
100.

H_I / H_U
10.

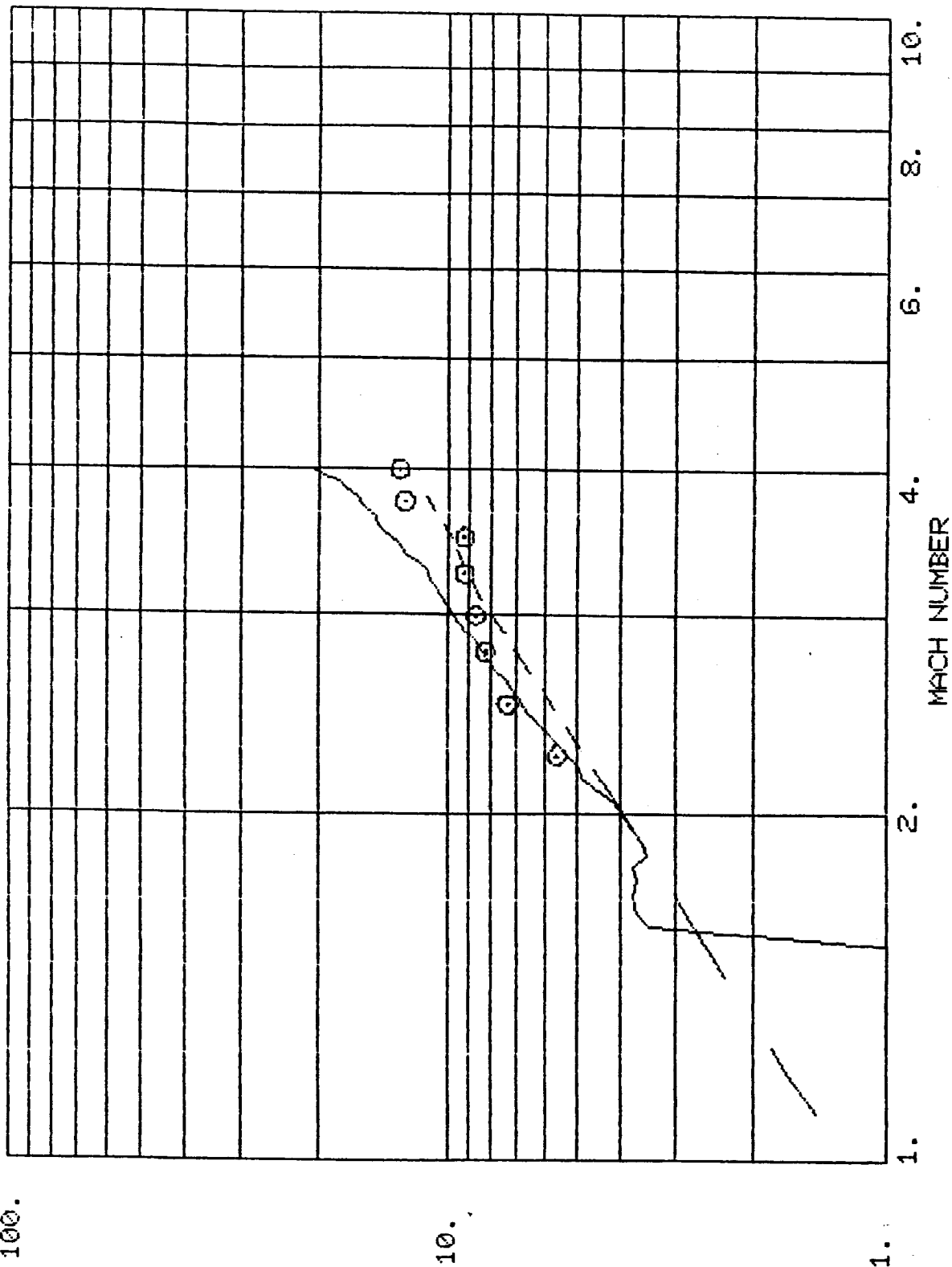


Fig. 4.11

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9016, ISLAND 14

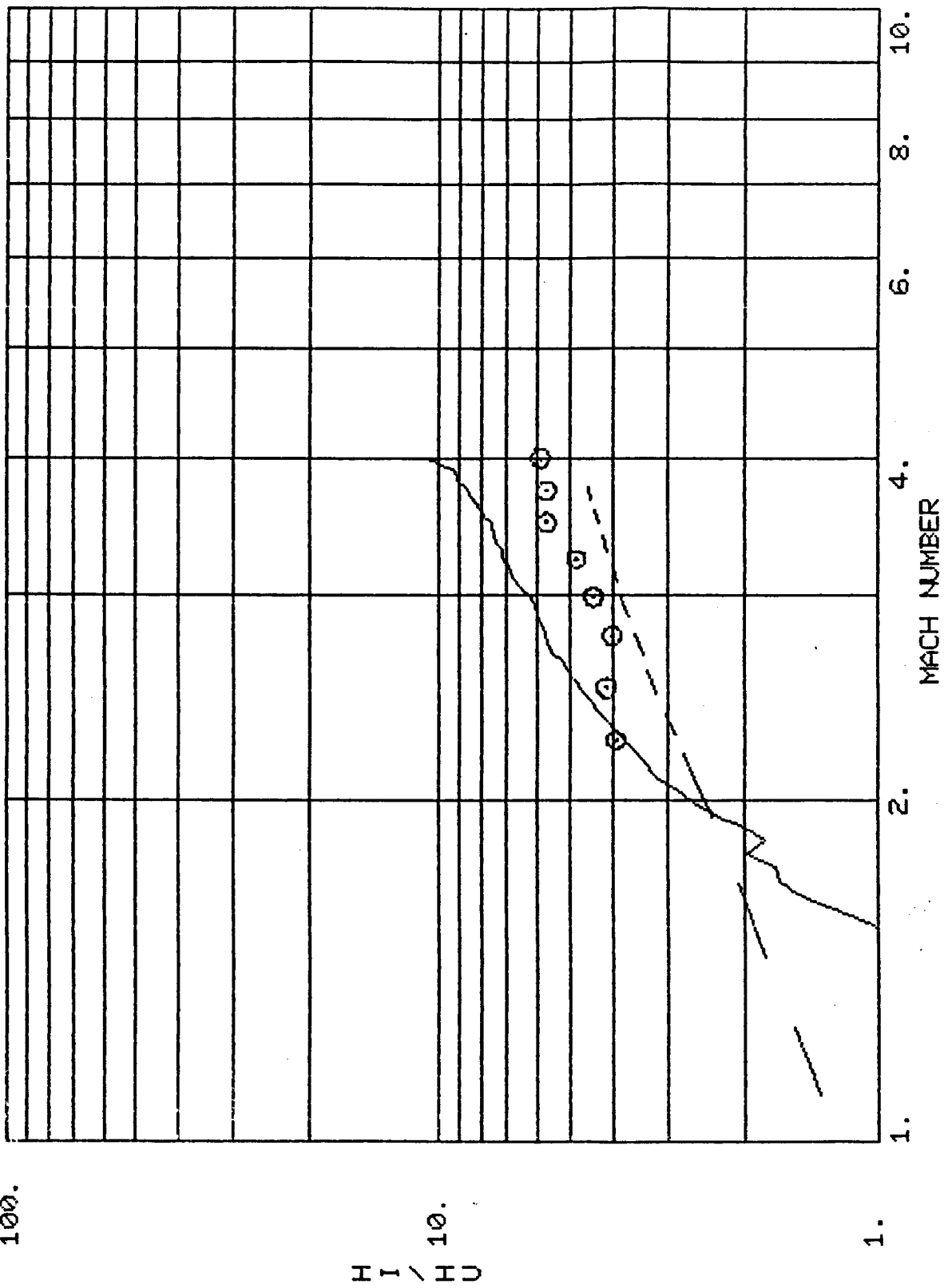


Fig. 4.12

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9017, ISLAND 12

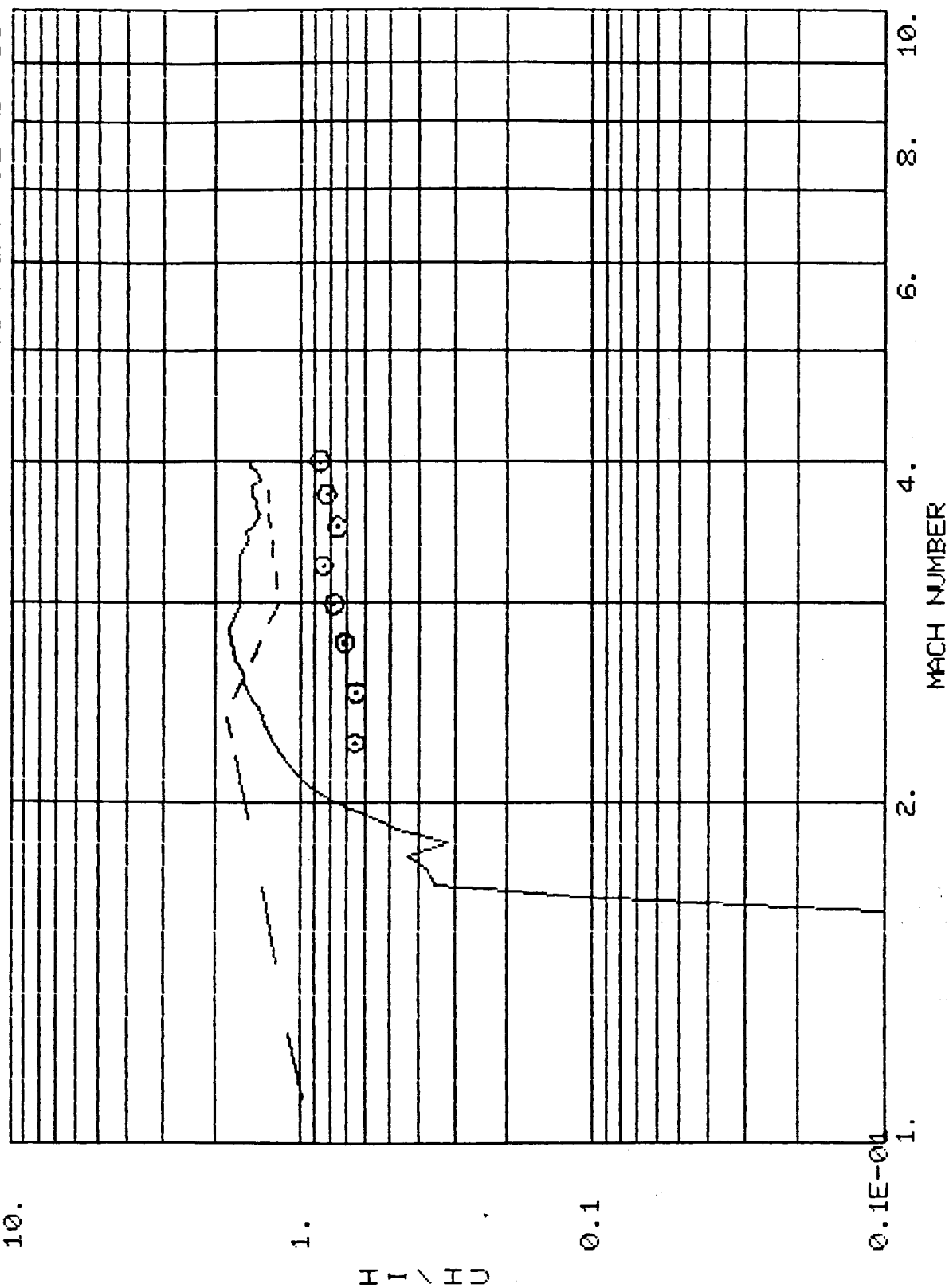


Fig. 4.13

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9018, ISLAND 172
100.

H I / H U
10.

1.

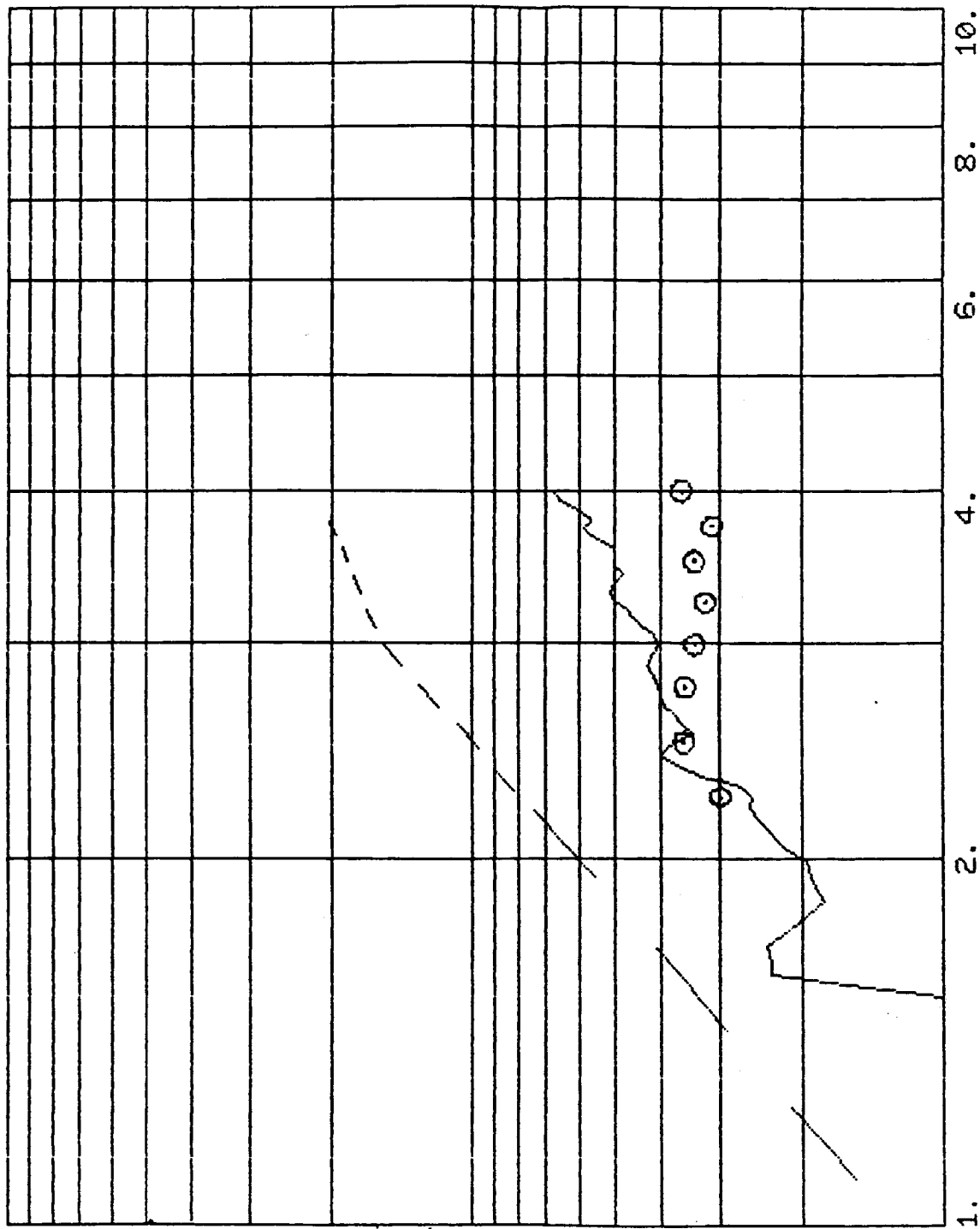


Fig. 4.14

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9019, ISLAND 171
10.

H I \ H D

1.

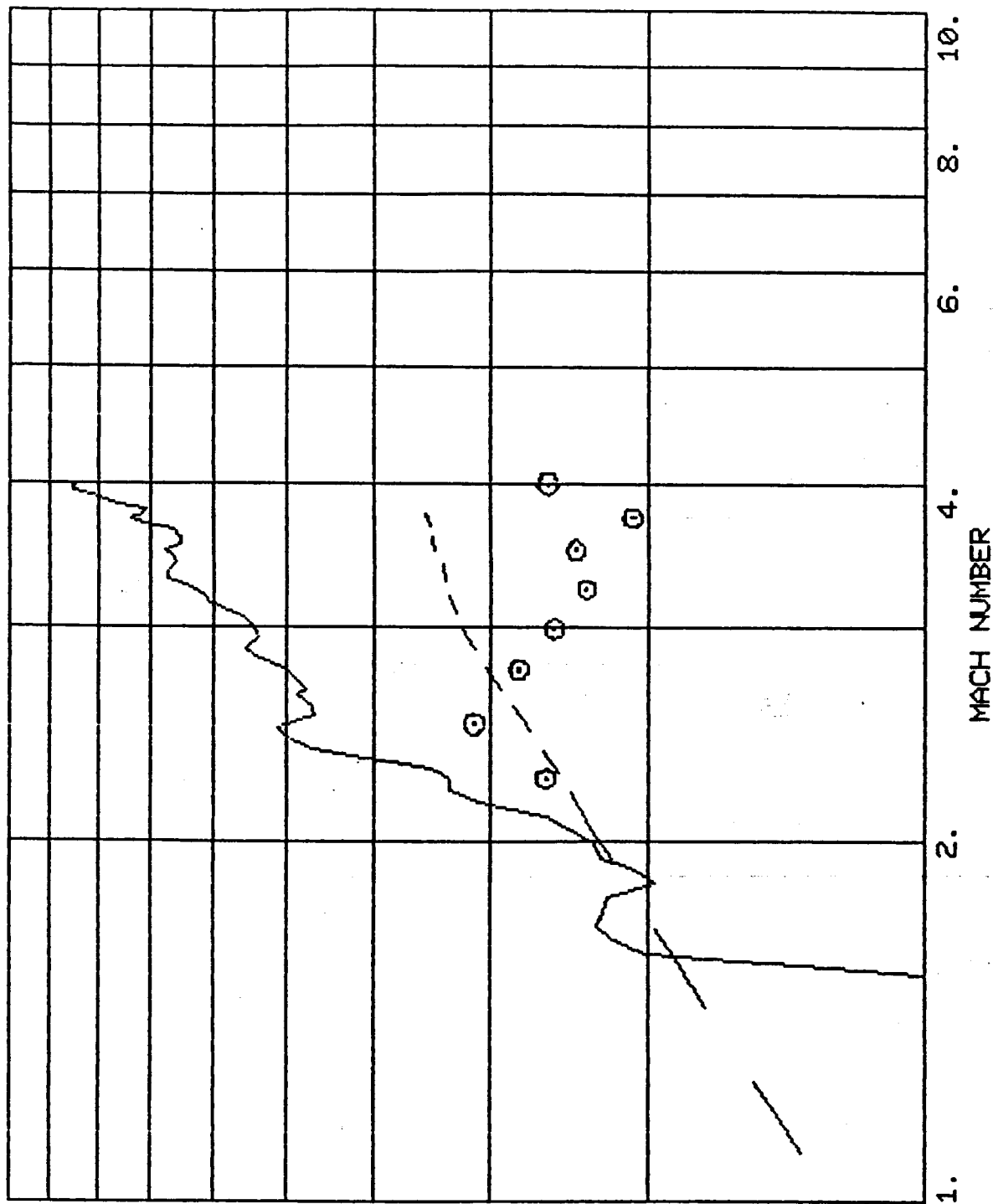


Fig. 4.15

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9020, ISLAND 27
100.

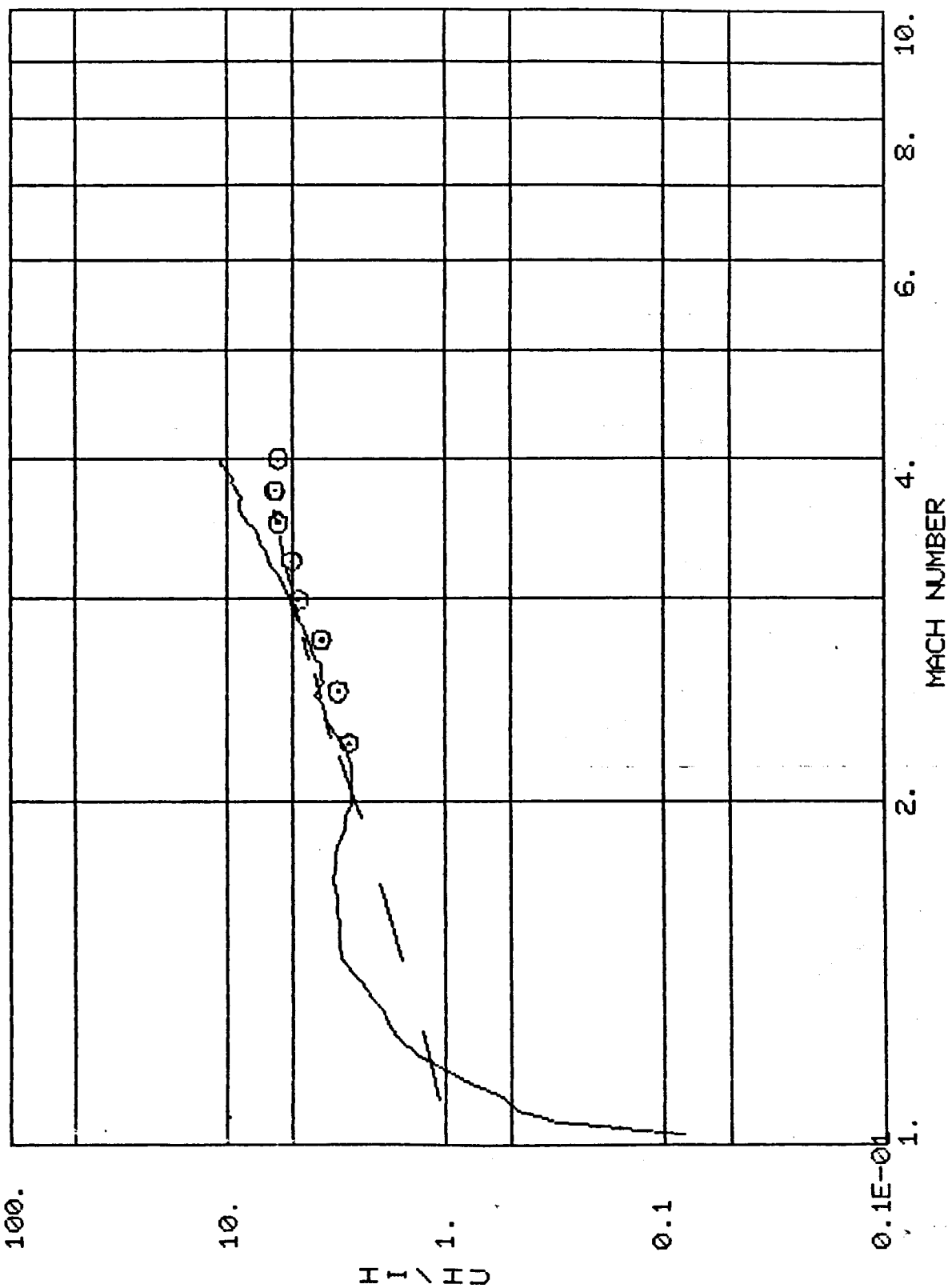


Fig. 4.16

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9021, ISLAND 20 10.

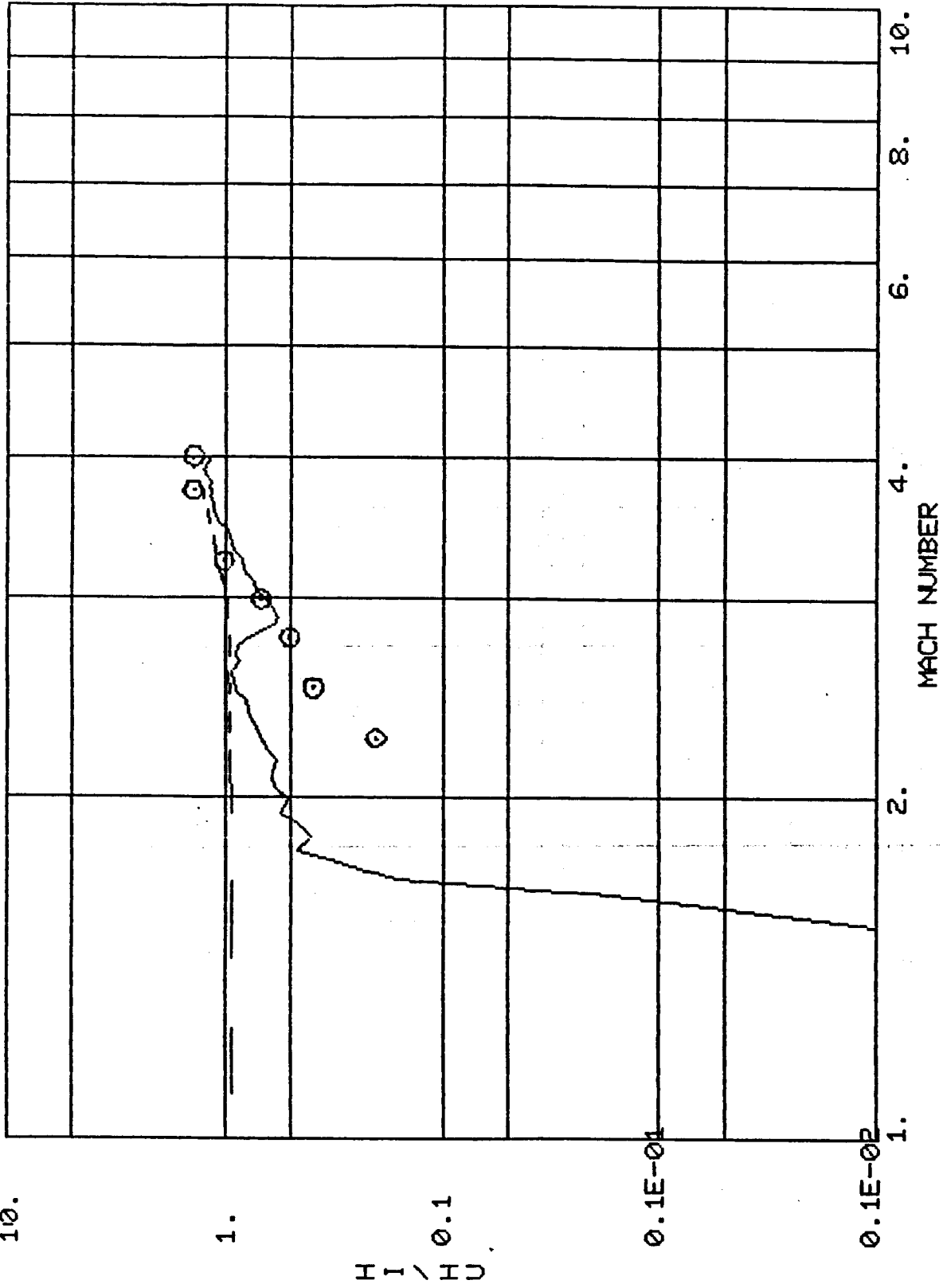


Fig. 4.17

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9022, ISLAND 23
10.

$\frac{H_I}{H_D} \sim 1.$

0.1

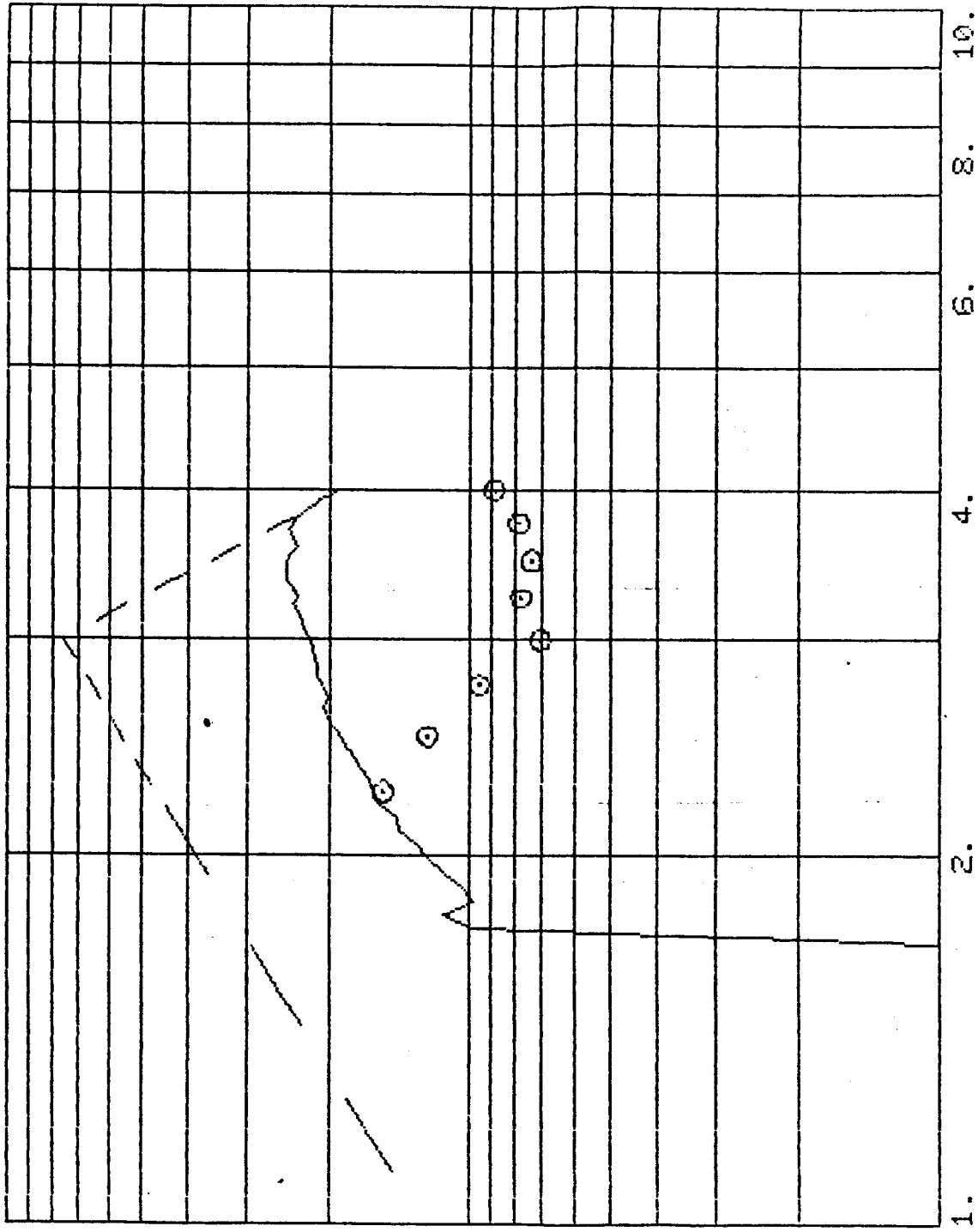


Fig. 4.18

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9023, ISLAND 26
100.

$\frac{H_I}{H_U} \times 100$

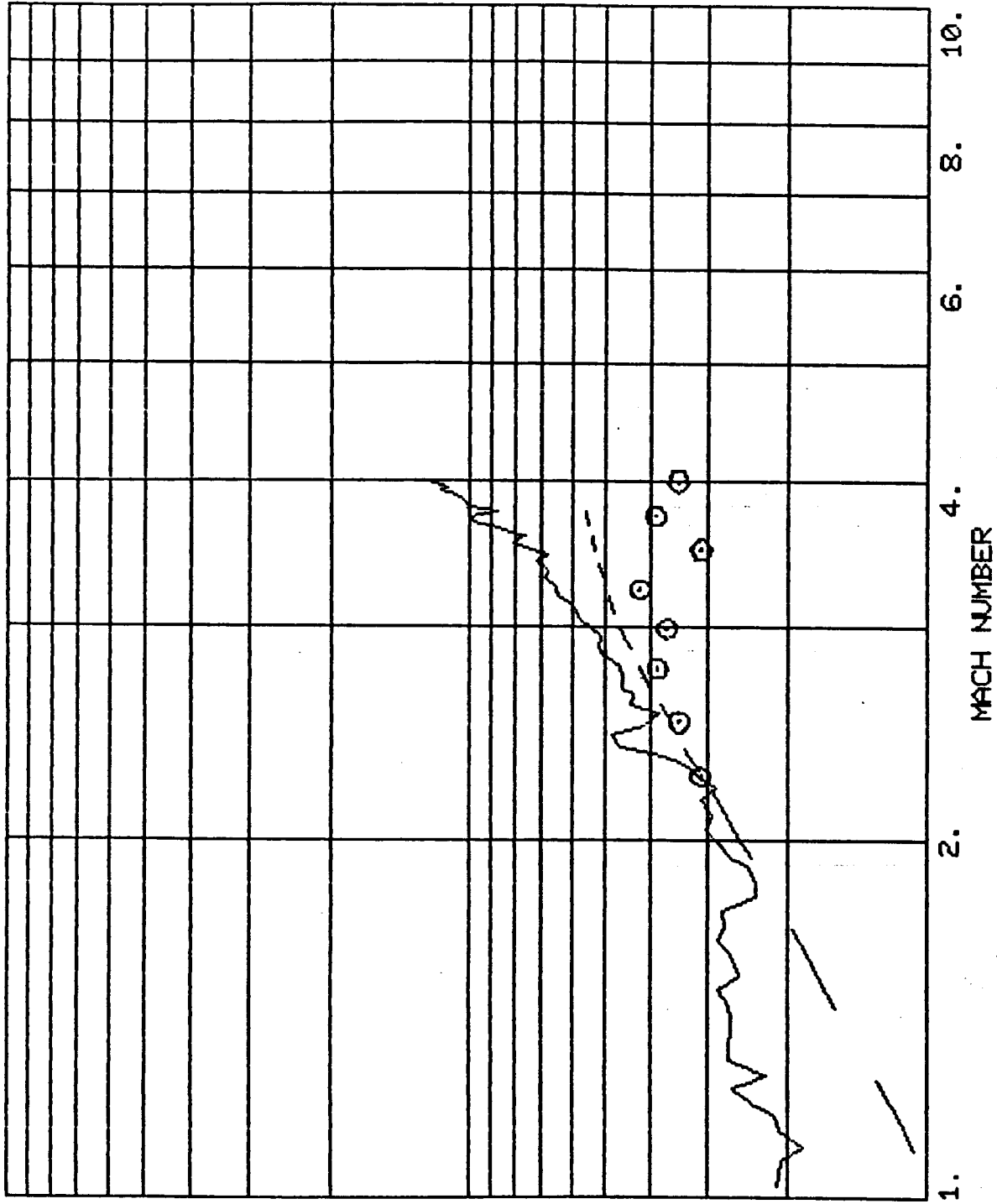


Fig. 4.19

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9025, ISLAND 29

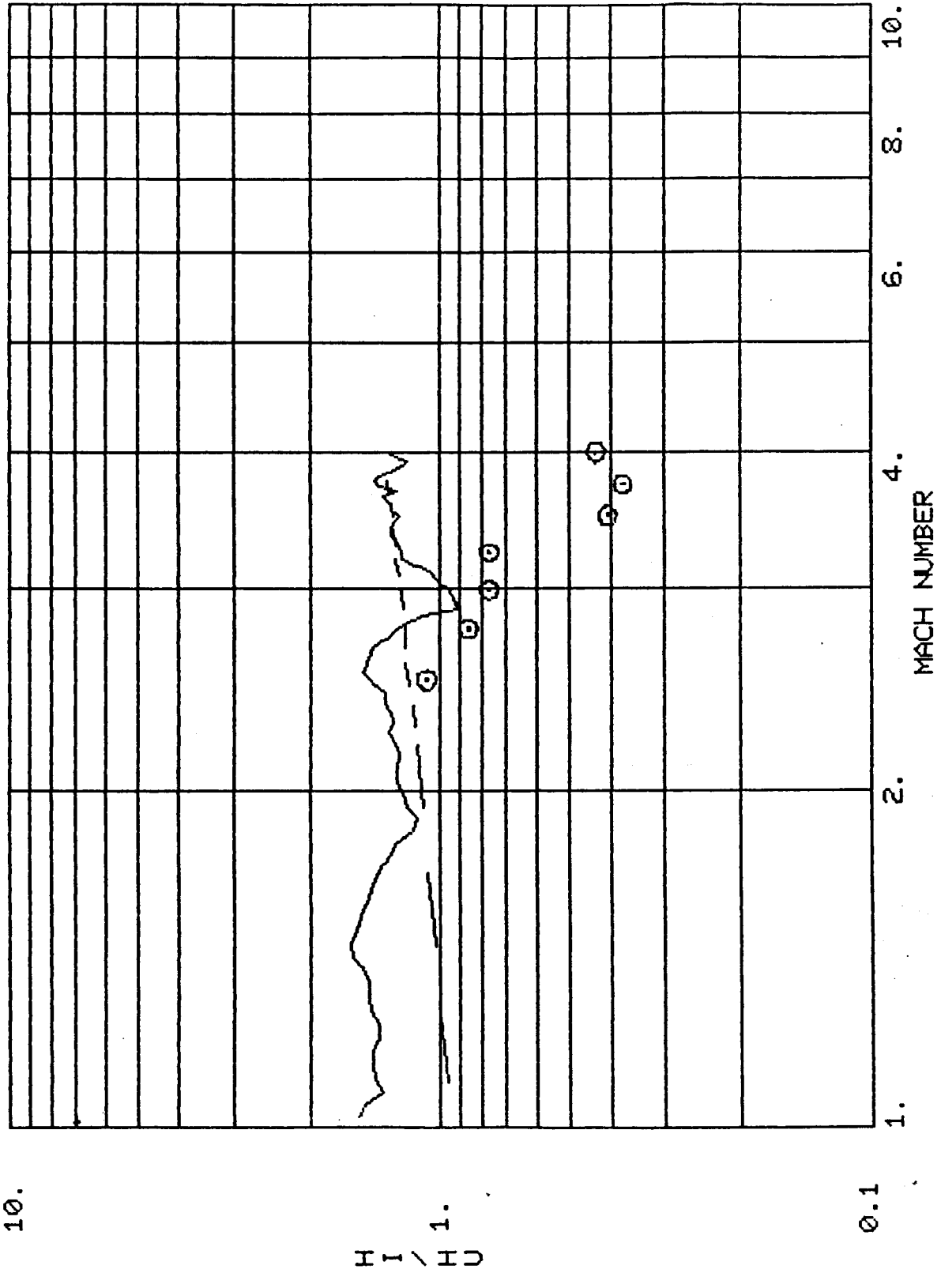


Fig. 4.20

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9026, ISLAND 28

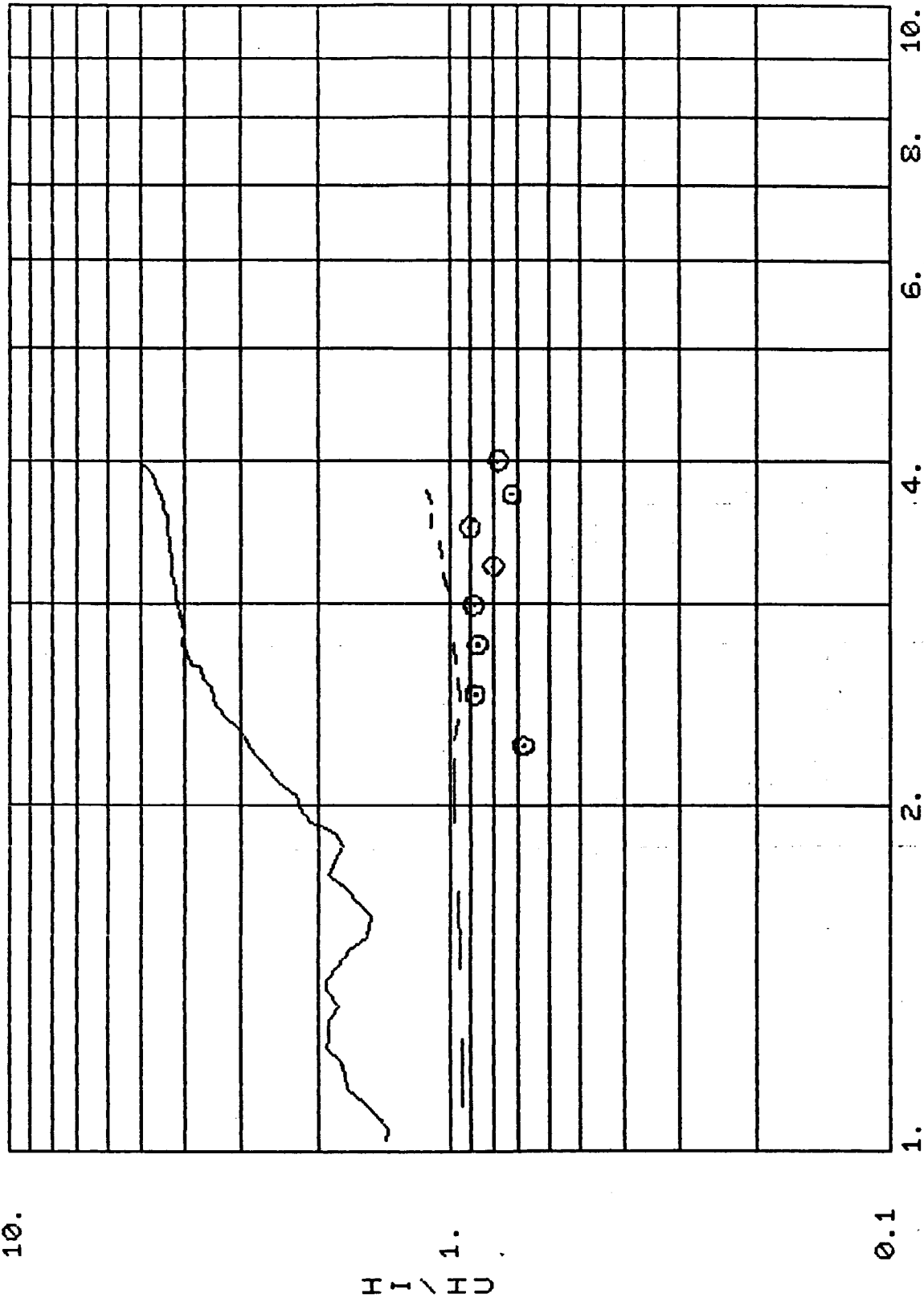


Fig. 4.21

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9027, ISLAND 33
10.

HI / HU
1.

0.1

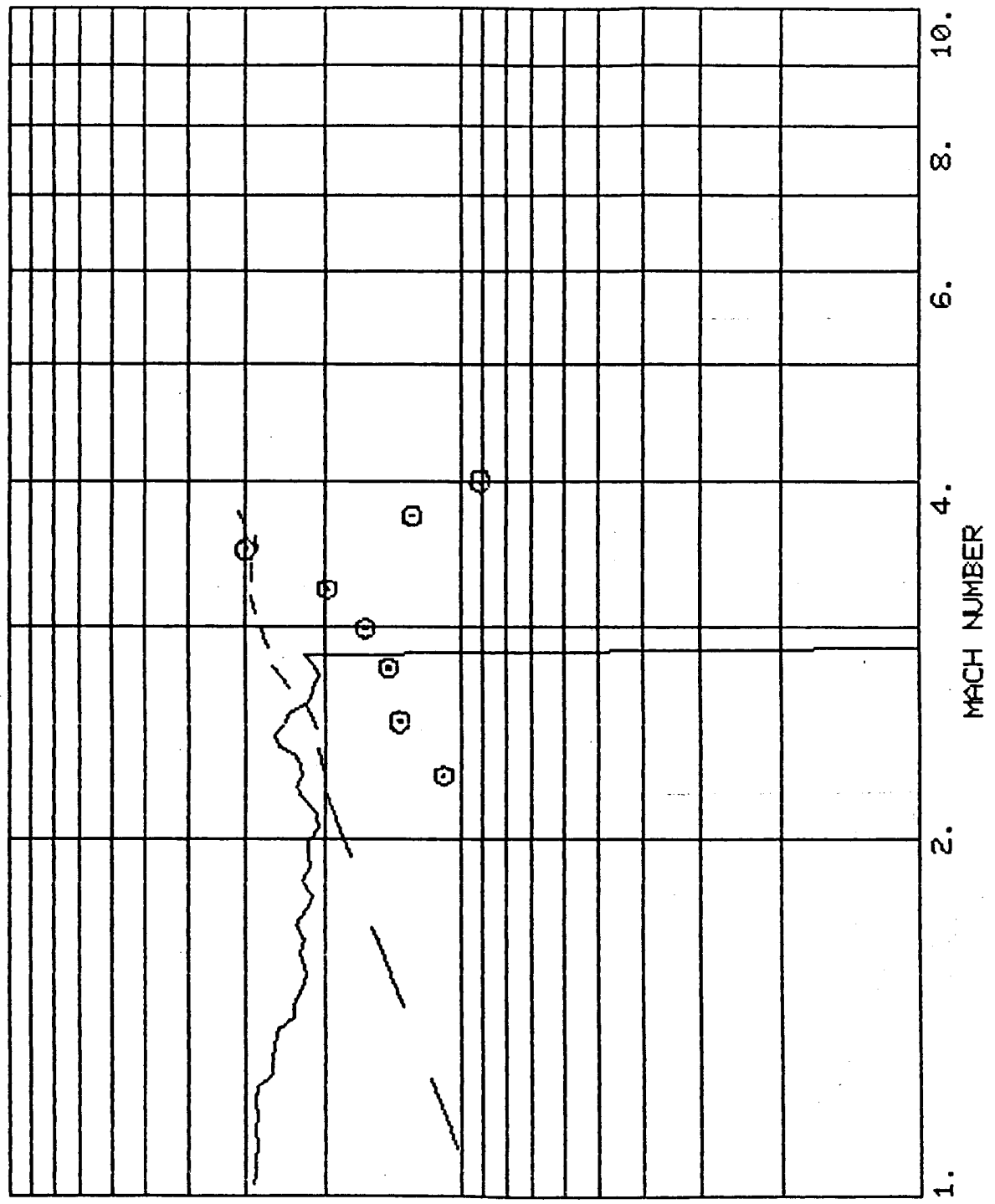


Fig. 4.22

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9028, ISLAND 35 10.

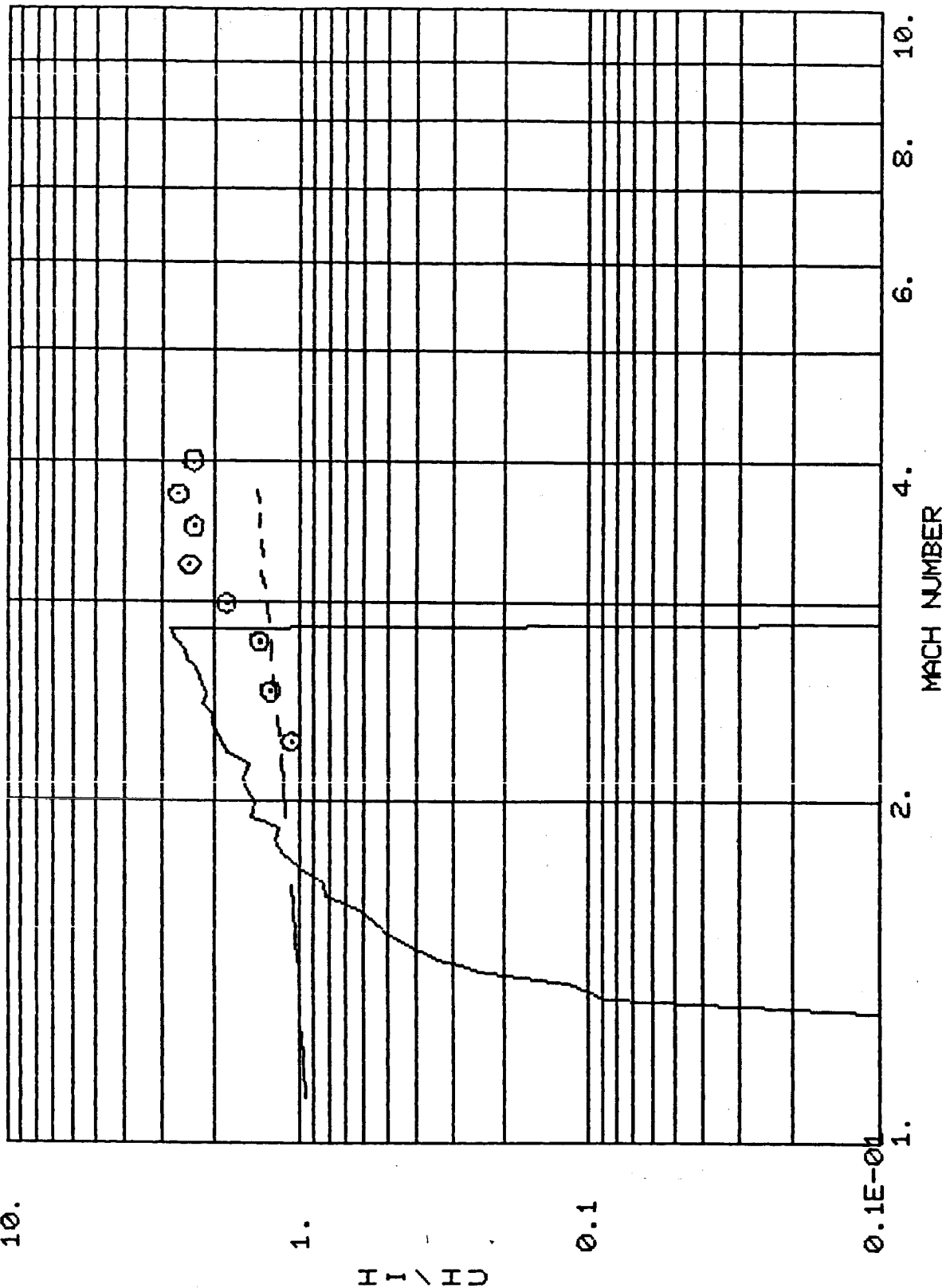


Fig. 4.23

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9029, ISLAND 32

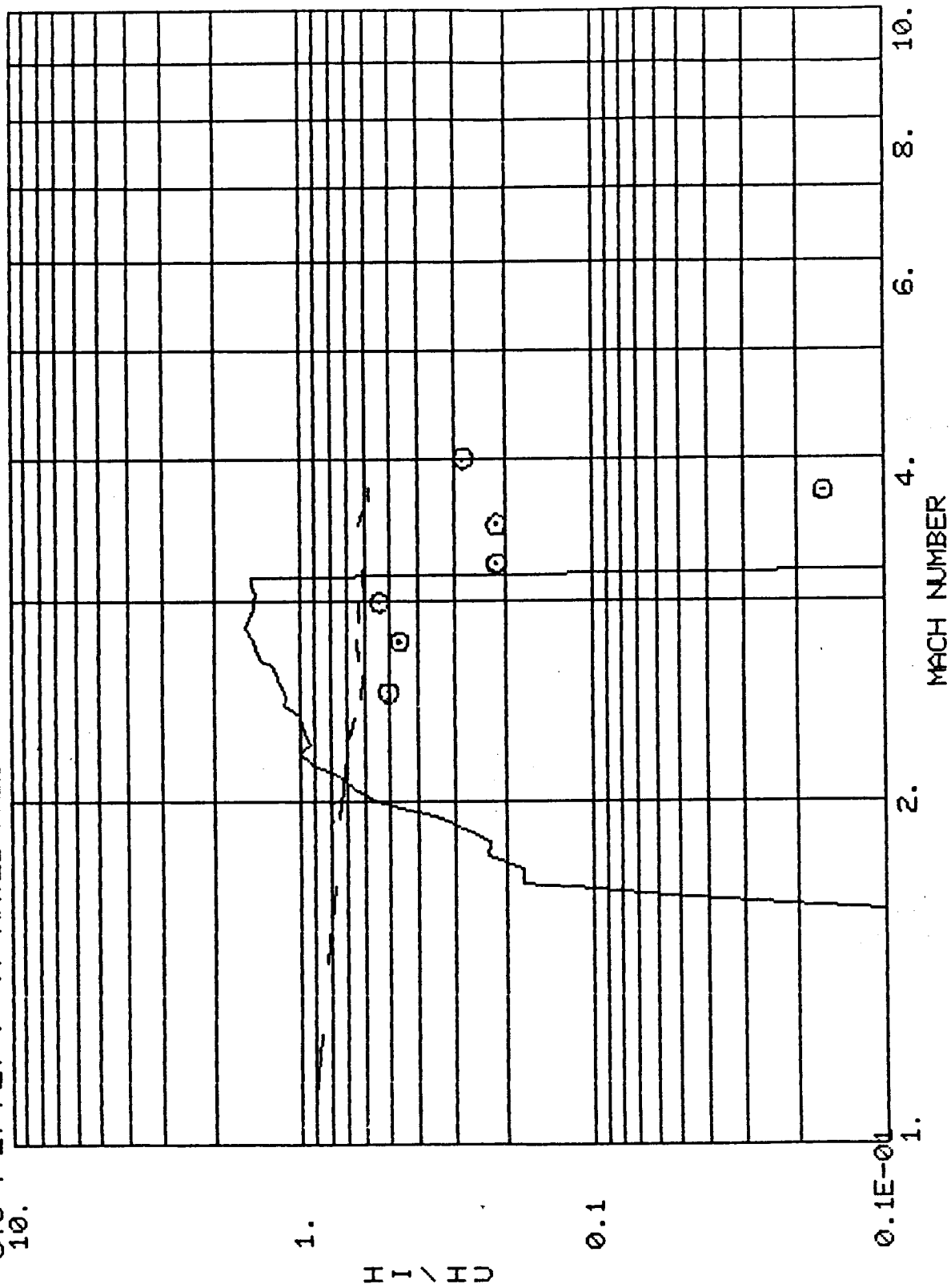


Fig. 4.24

$\frac{H_I}{H_U} \times 10.$

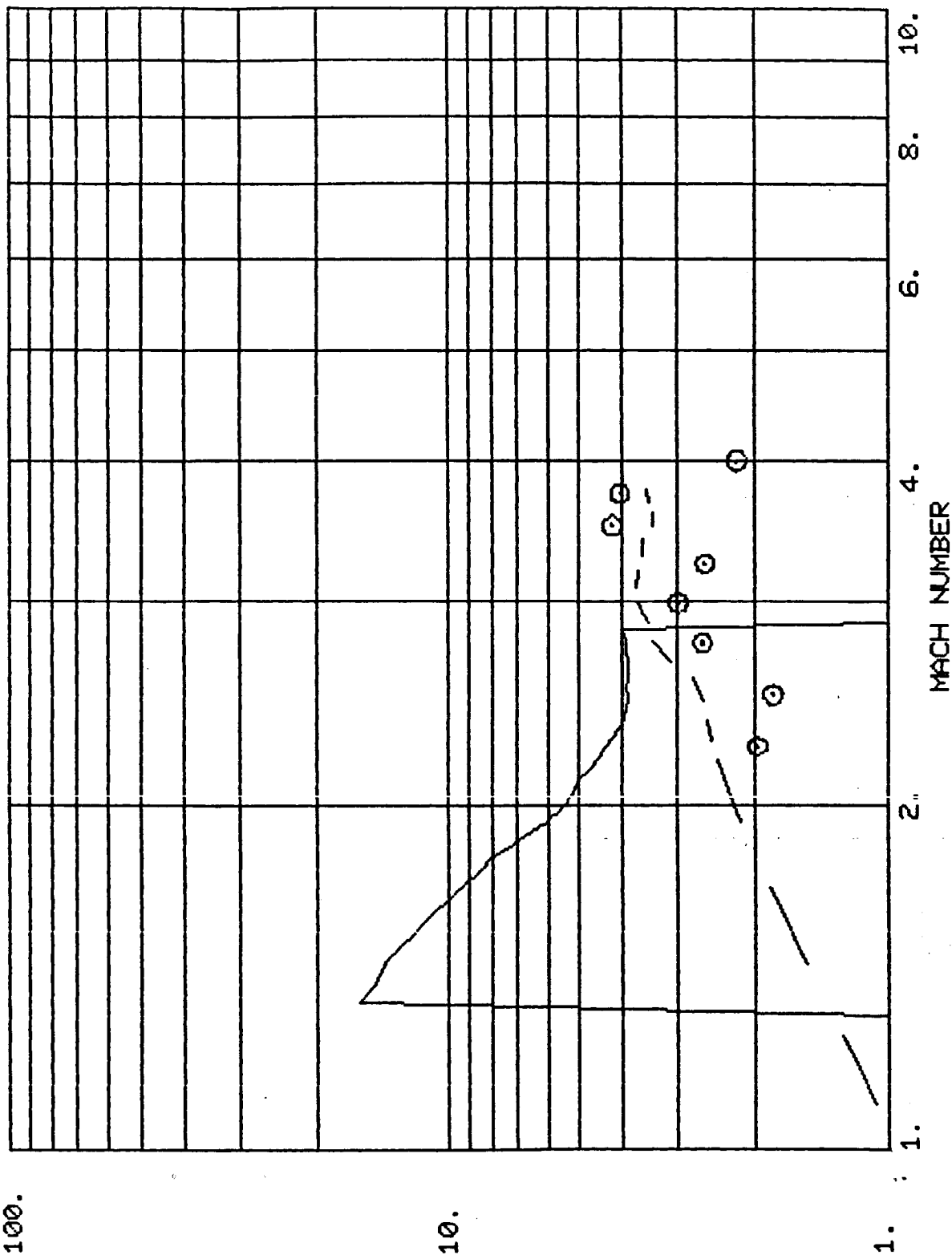


Fig. 4.25

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9031, ISLAND 36
10.

H_I / H_U
1.

0.1

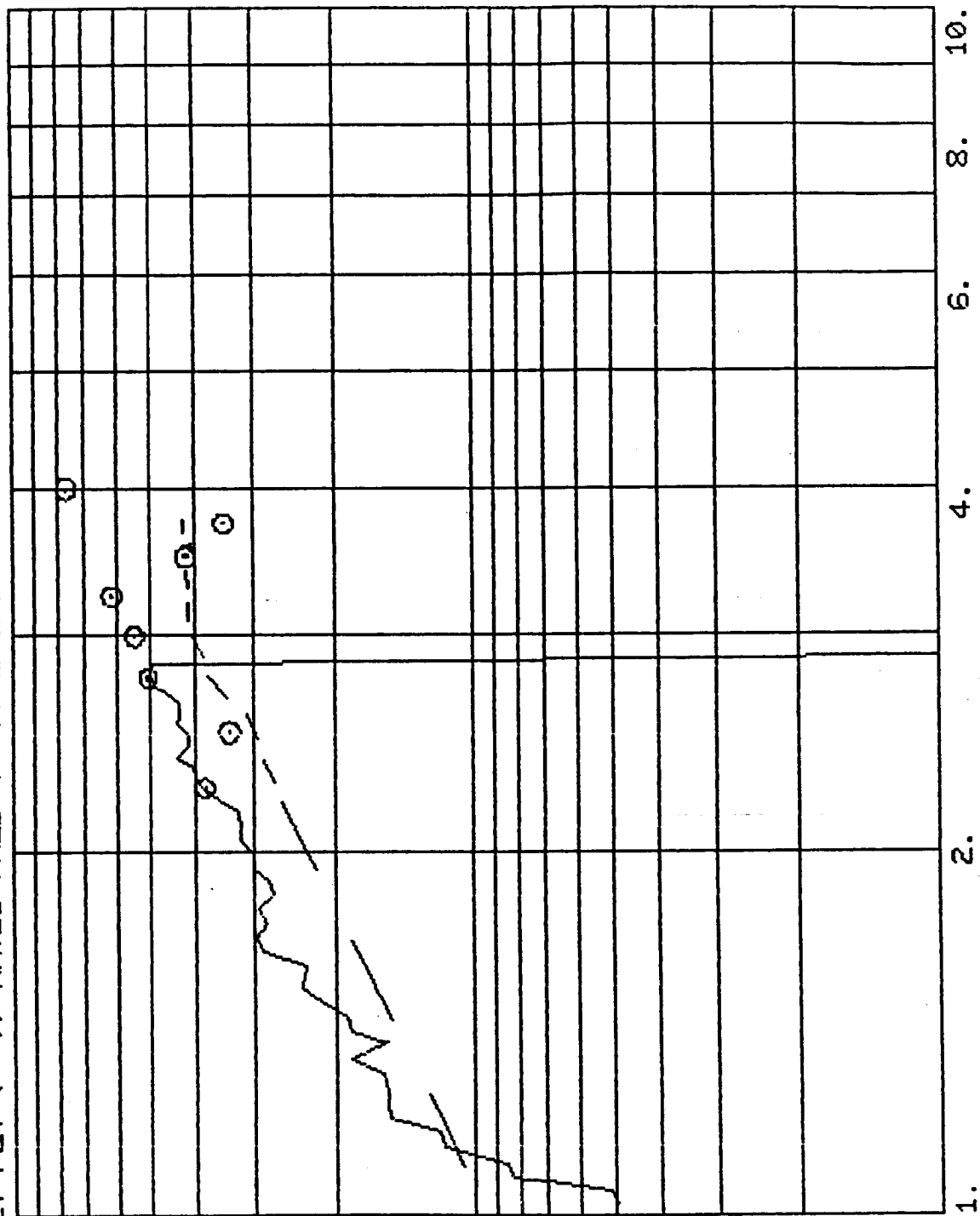


Fig. 4.26

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9032, ISLAND 37
10.

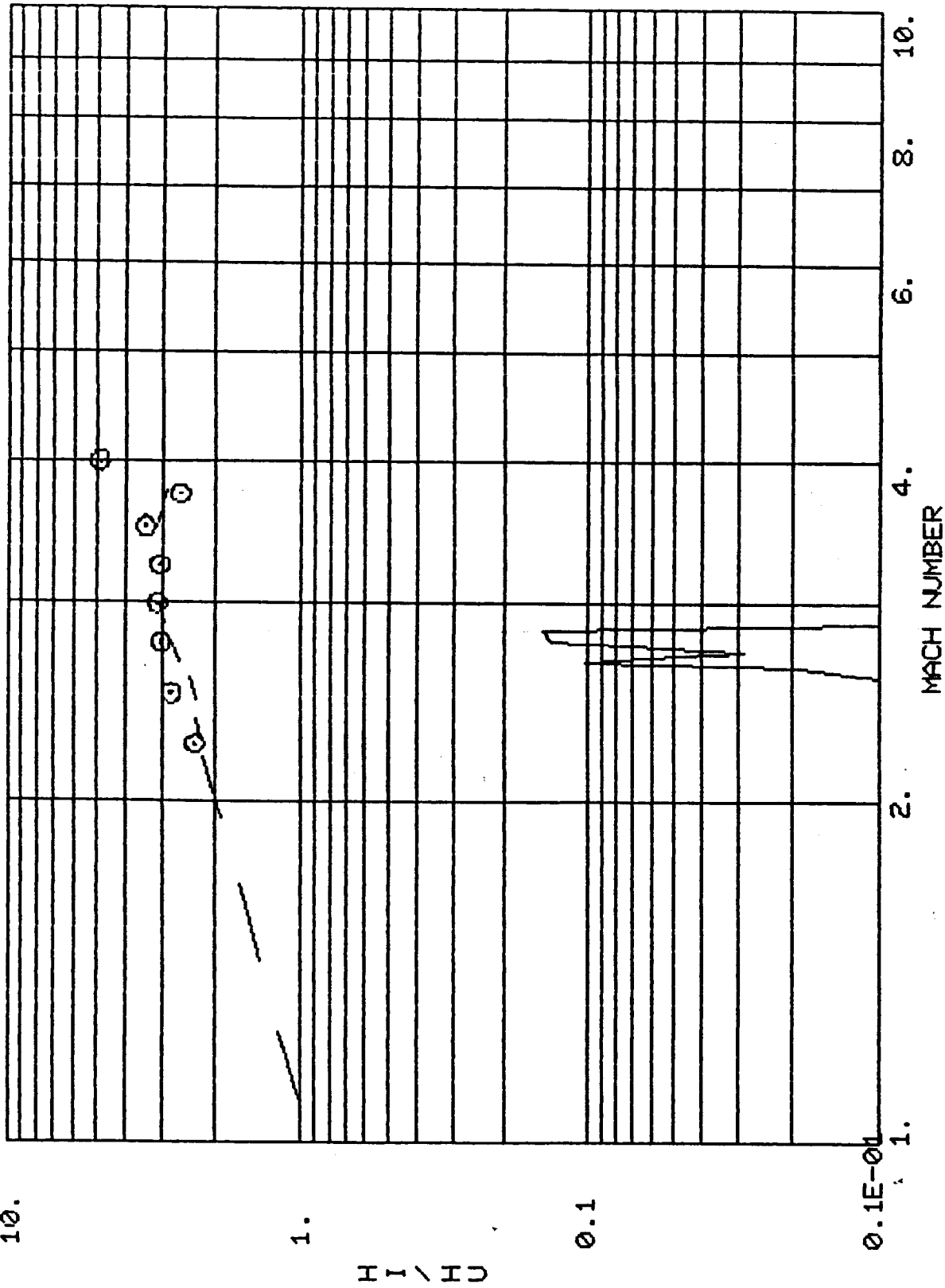


Fig. 4.27

STS-4 ET FLT DATA (—) & RATE1 PRED (---) - GAGE 9038, ISLAND XXX

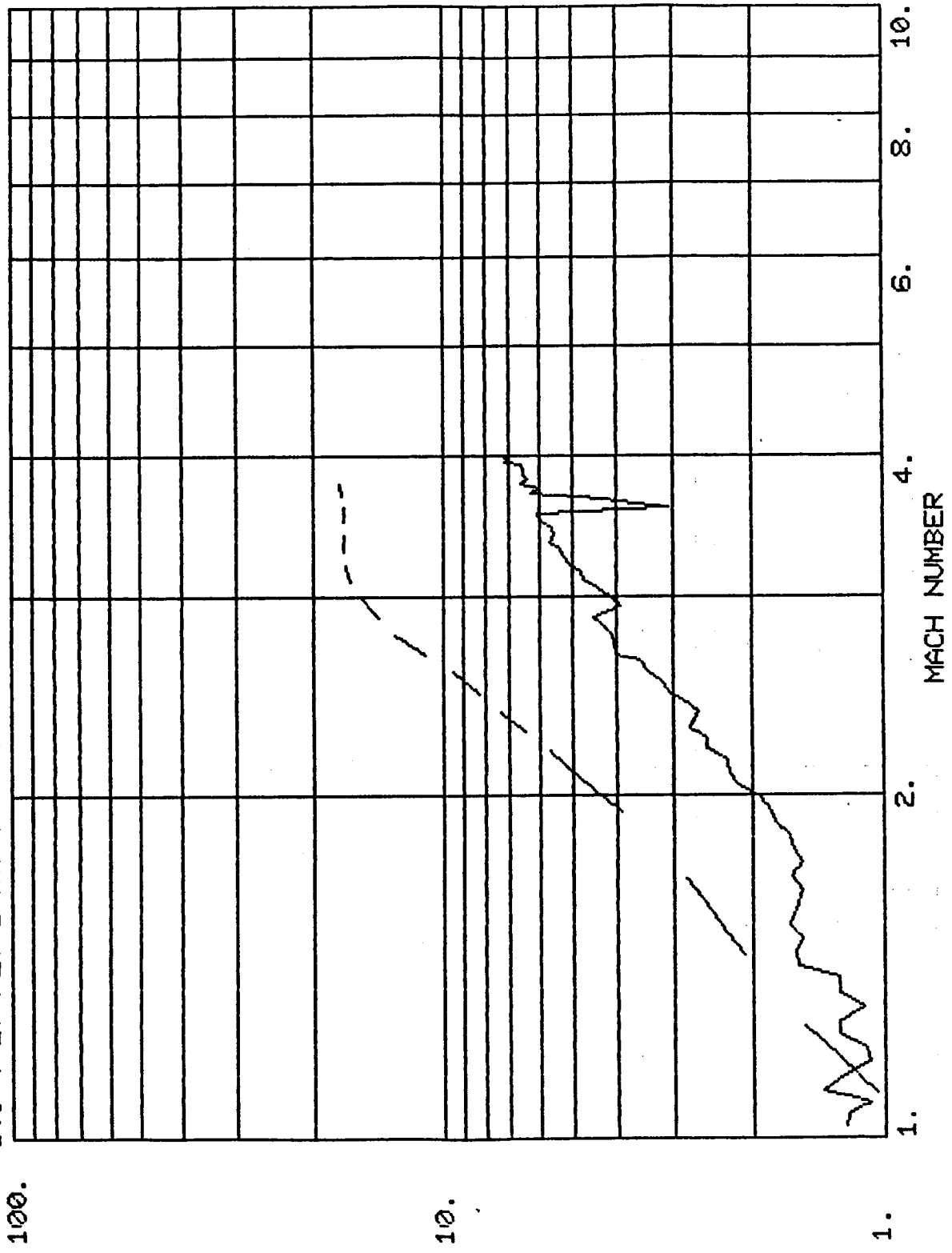


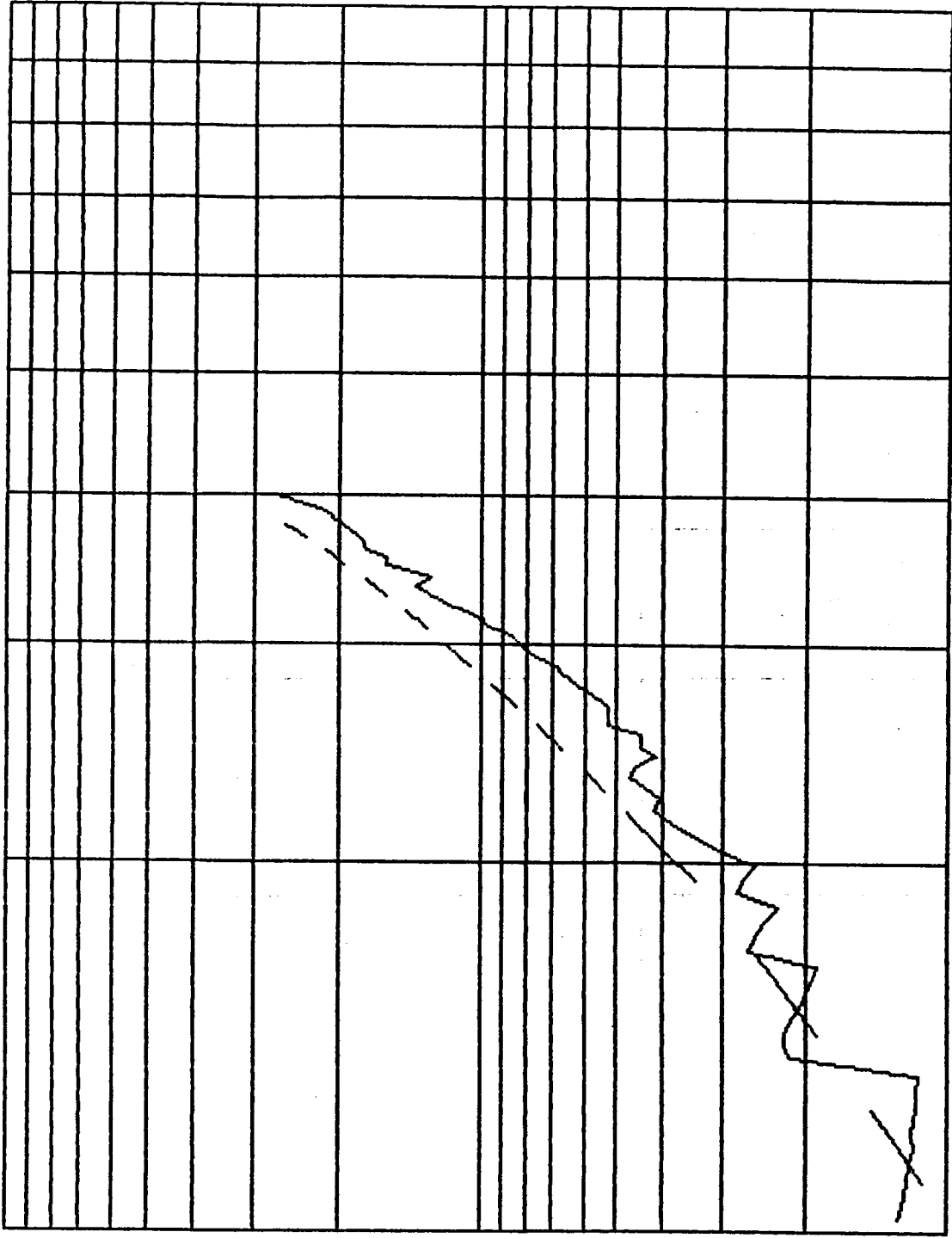
Fig. 4.28

STS-4 ET FLT DATA (—) & RATE1 PRED (- -) - GAGE 9039, ISLAND XXX

100.

$\frac{H_I}{H_D}$ 10.

1.



1. 2. 4. 6. 8. 10.

MACH NUMBER

Fig. 4.29

STS-4 ET FLT DATA (—) & RATE1 PRED (---) - GAGE 9041, ISLAND XXX

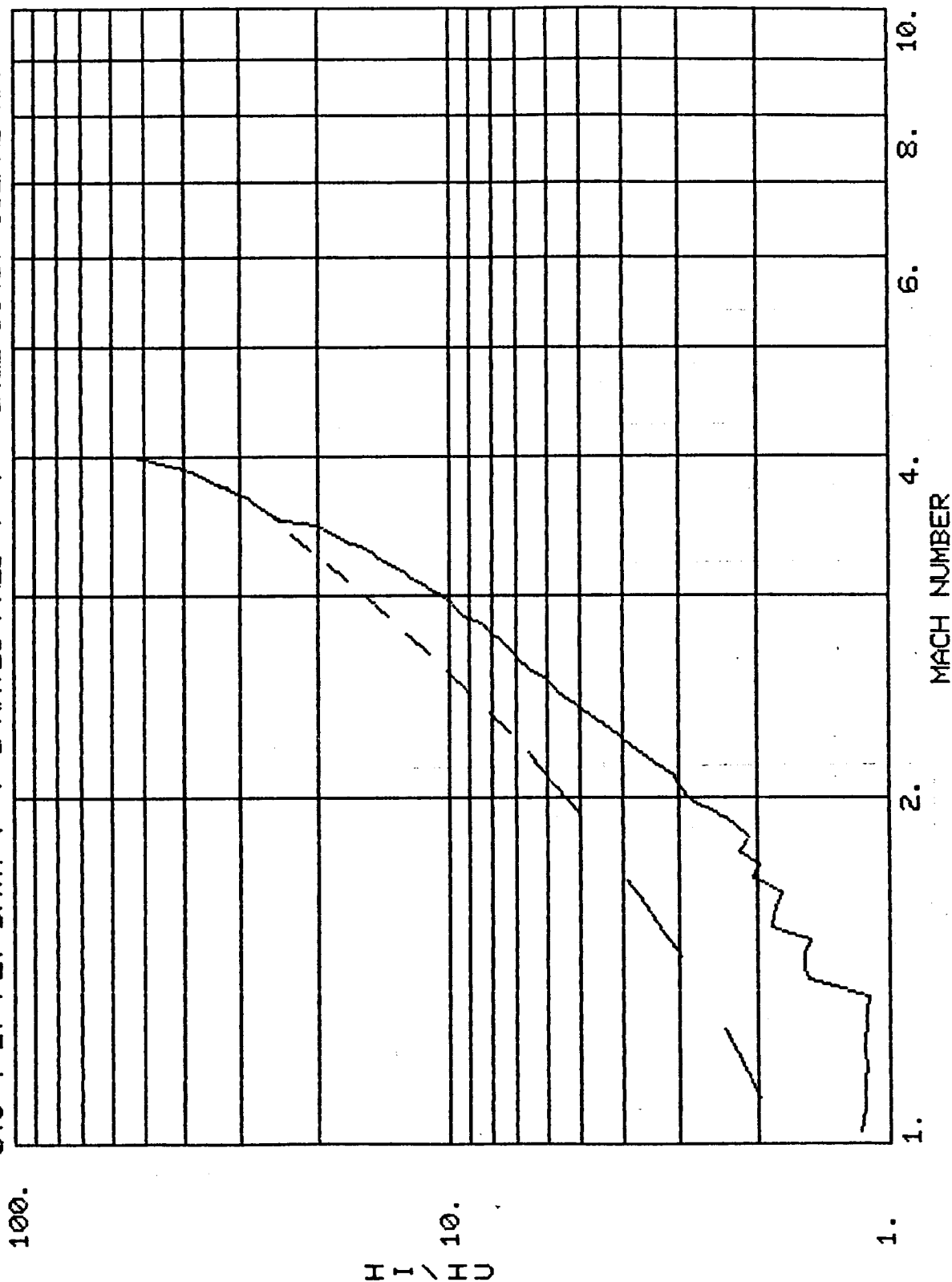


Fig. 4.30

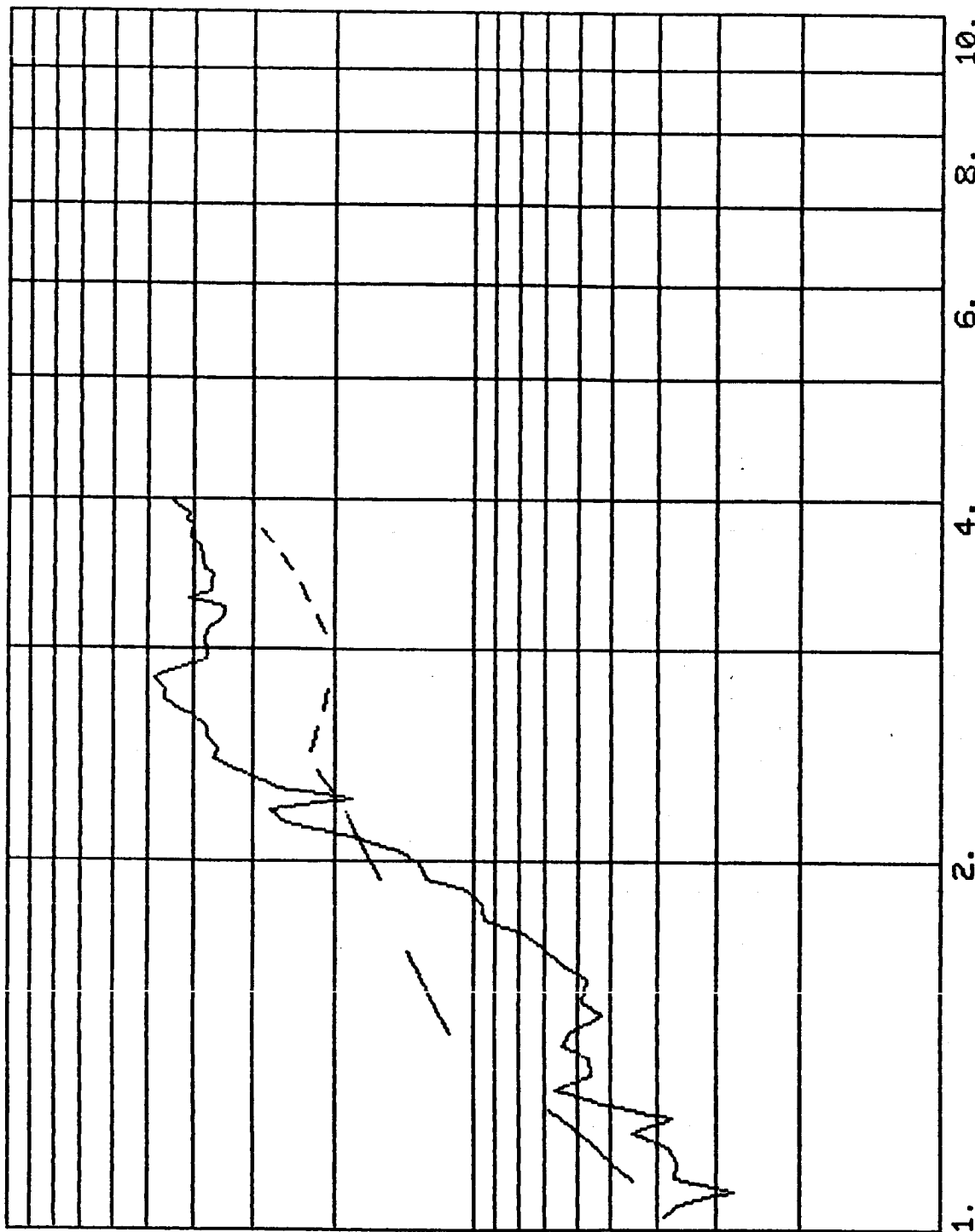
STS-4 ET FLT DATA (—) & RATE1 FRED (---) - GAGE 9042, ISLAND XXX

10.

H_I / H_D

1.

0.1



MACH NUMBER

Fig. 4.31

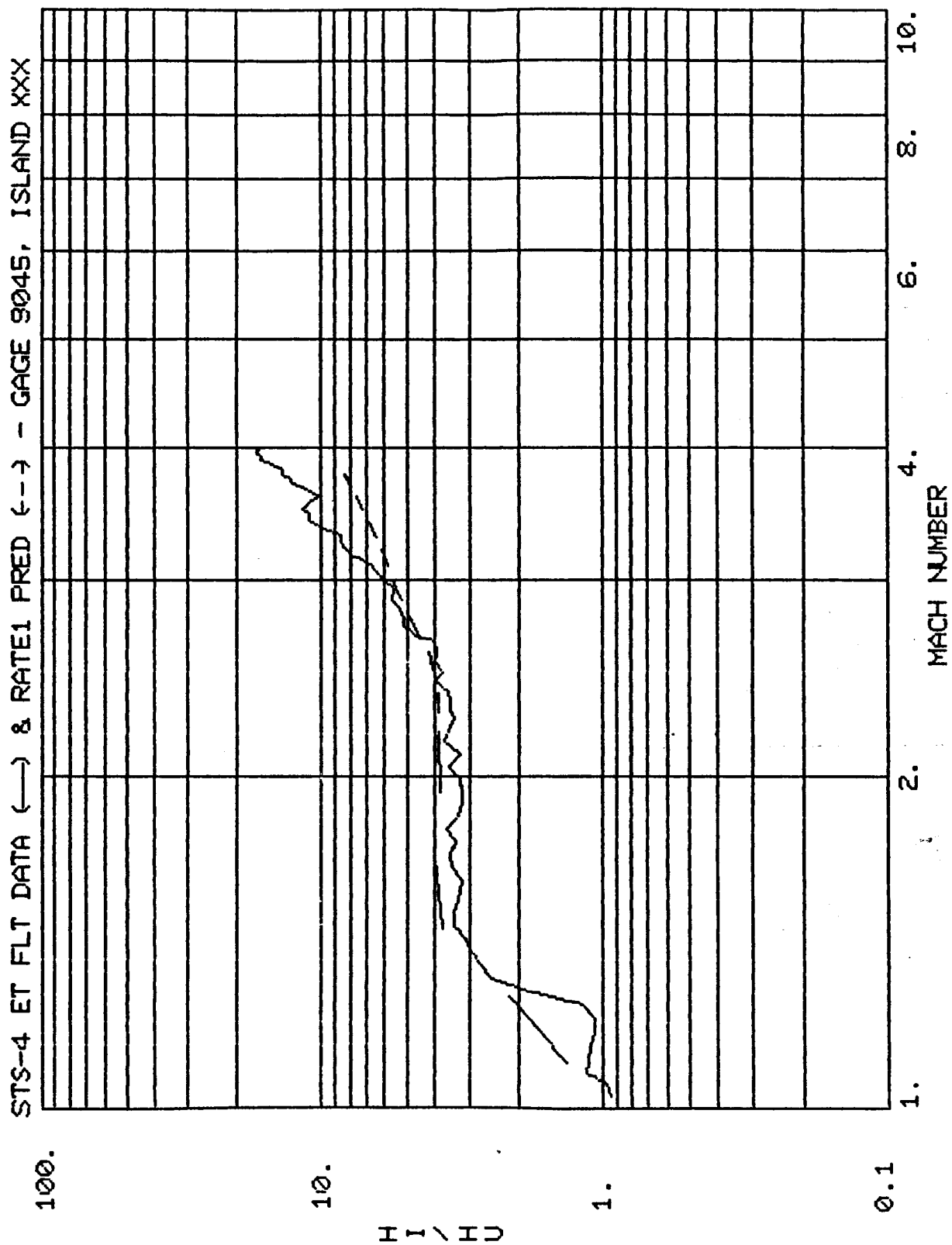


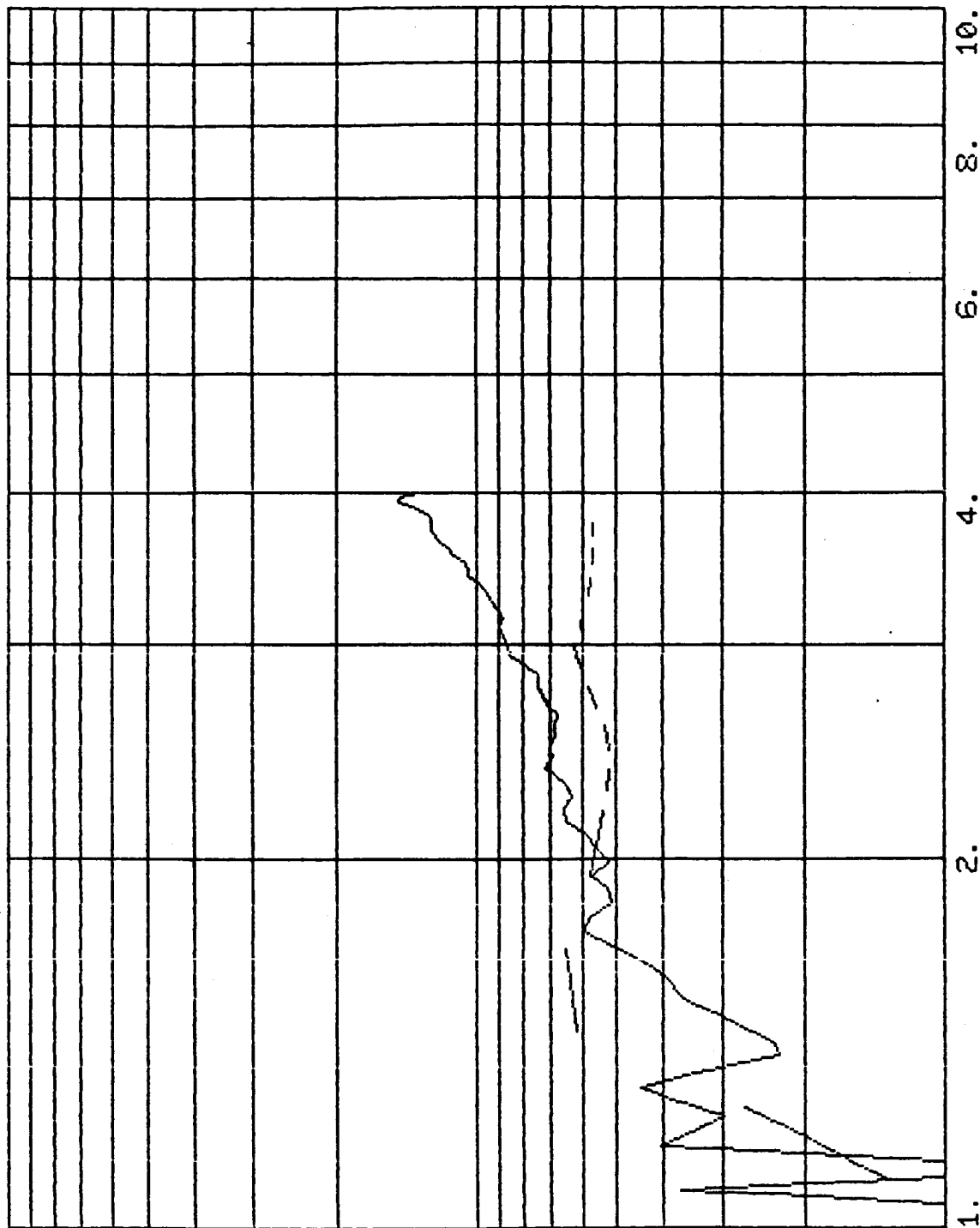
Fig. 4.32

STS-4 ET FLT DATA (—) & RATE1 PRED (---) - GAGE 9046, ISLAND XXX

100.

$\frac{H_I}{H_U}$ 10.

1.



10.

8.

6.

4.

2.

1.

MACH NUMBER

Fig. 4.33

STS-4 ET FLT DATA (—) & RATE1 PRED (---) - GAGE 9047, ISLAND XXX

100.

$\frac{H_I}{H_U} \cdot 10.$

1.

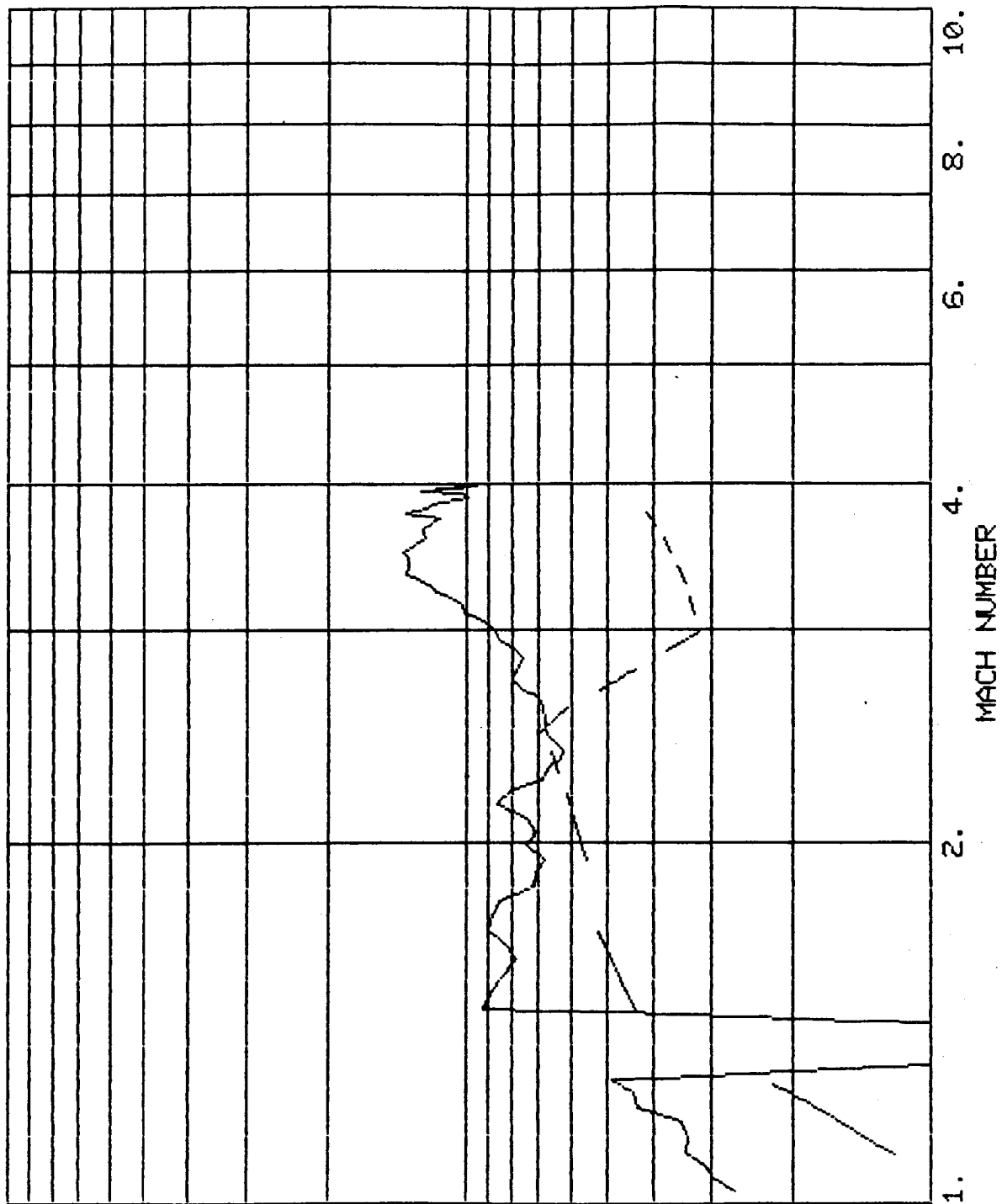


Fig. 4.34

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APPENDIX

SET-1

STS-1 pp. 1.1 - 1.10

TECHNICAL NOTE

TITLE: Comparison of Protuberance DFI Interference Factors Between
OFT Flight, Prediction and IH-97A Test Data
(From RTN 041-15A)

DATE: September 26, 1983

AUTHORS: Dr. Sarat C. Praharaj and Donald R. Hulsey

CONTRACT NO: NAS8-33373

PREPARED FOR: George C. Marshall Space Flight Center

DESCRIPTION

This technical note is an addendum to the note, RTN 041-15, which was prepared to compare the OTS turbulent interference factors on acreage DFI locations from flight data prediction and IH-97A test data. The purpose of this note is to present the protuberance DFI interference factor (h_l/h_u) vs. Mach number plots comparing OFT flight data, prediction and IH-97A test data. They are given in the following four sets of plots which are attached as Appendix to this note.

Set 1 - STS-1 pp. 1.1-1.10
 Set 2 - STS-2 pp. 2.1-2.10
 Set 3 - STS-3 pp. 3.1-3.10
 Set 4 - STS-4 pp. 4.1-4.10

Each of the above sets contains tables summarizing the h_l/h_u data from test IH-97A for the protuberance DFI locations. A typical plot compares h_l/h_u data derived from flight measurements, h_l/h_u prediction based on the wind tunnel data base, and h_l/h_u data obtained from test IH-97A. The data reduction procedure

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for the flight data is documented elsewhere (Ref. 1). The prediction procedure, which is common to all flights, is described in detail for STS-1 in Ref. 2. As far as the ET protuberance DFI data in test IH-97A, the tabulated data are reported in Ref. 3. It should be noted here that the h_u values in the h_l/h_u data for all the above plots are based on the flat-plate values calculated on the ET skin. It should further be noted that this flat-plate h_u value can easily be changed to an undisturbed value corresponding to a protuberance by a multiplier while considering the turbulent regime.

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REFERENCES

1. Praharaj, S. C. and Engel, C. D., "STS Orbital Flight Test (OFT) External Tank Aerothermal Flight Evaluation," REMTECH, Inc., Huntsville, Alabama, Technical Report (Under Preparation).
2. Praharaj, S. C. and Engel, C. D., "STS-1 ET Aerothermal Flight Evaluation," REMTECH, Inc., Huntsville, Alabama, Technical Report 041-1, April 1982.
3. Somers, R. E. and Warmbrod, J. D., "External Tank Protuberance Heat Transfer Data Tables For Test IH-97A," REMTECH, Inc., Huntsville, Alabama, Report RM 032-10, August 1983.

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APPENDIX

SET-1

STS-1 pp. 1.1 - 1.10

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Table 1.1 STS-1 PROTUBERANCE DFI LOCATIONS

MEASUREMENT I.D.	XT (IN.)	THETA (DEG.)	GAGE TYPE	LOCATION
T07R9012A	1008.0	21.0	Ind. Gage	L02 Fdln. Fairing (side)
T07R9038A	996.0	23.0	Ind. Gage	L02 Fdln. Fairing (top)
T07R9039A	1129.9	356.0	Ind. Gage	ET/ORB Fwd LH Strut
T07R9041A	959.2	270.0	Ind. Gage	Bolt Catcher
T07R9042A	2002.0	29.0	Ind. Gage	RH Thrust Strut
T07R9045A	2058.0	10.0	Ind. Gage	Aft Diag. Strut
T07R9046A	2054.0*	45.0	Ind. Gage	LH Vert Strut Cable Tray
T07R9047A	2030.0	26.0	Ind. Gage	Fwd. L02 Fdln/X-Beam Cable Tray

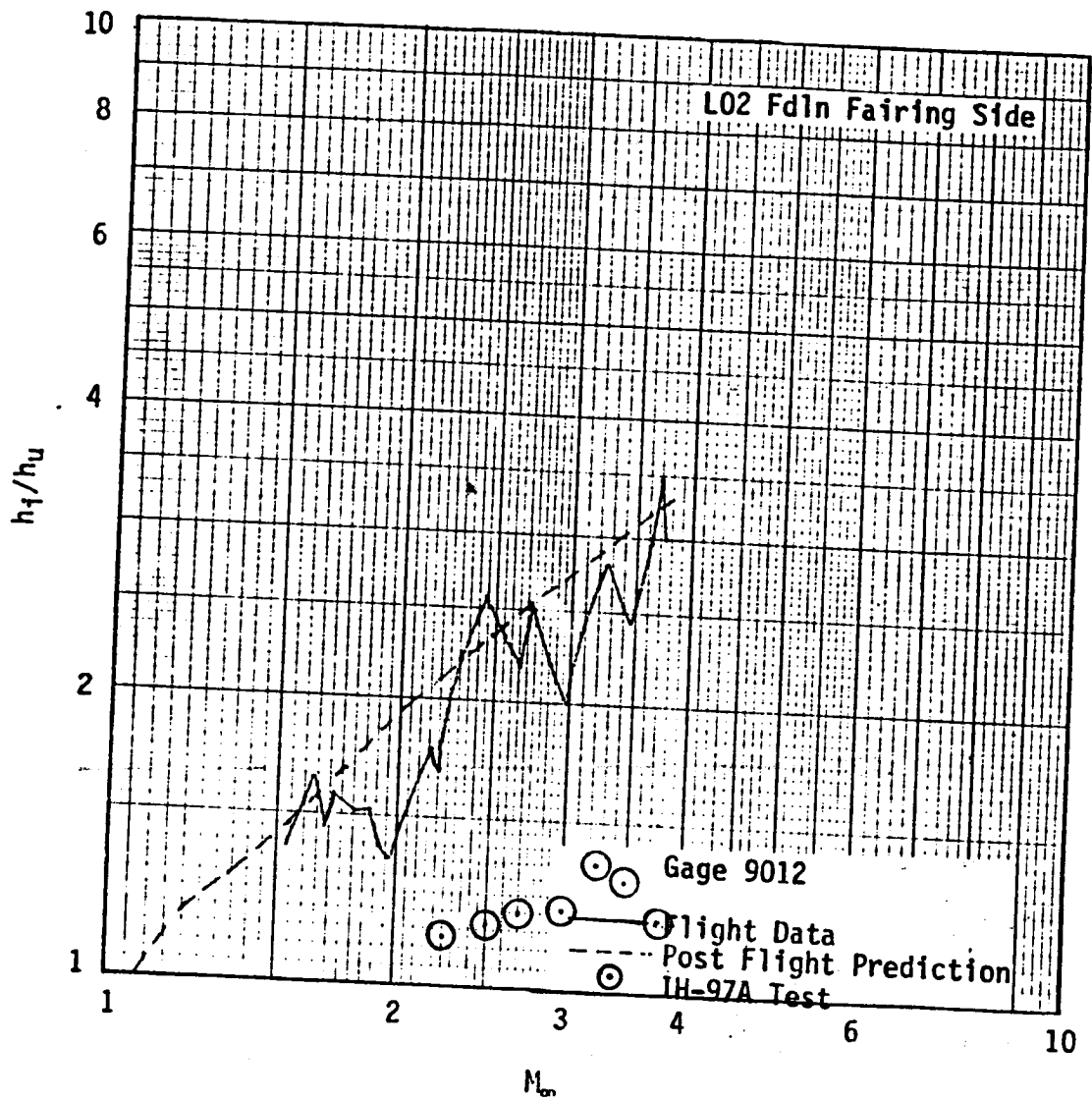
*X_T Distance corrected on September 23, 1983. The new value has no impact on any previous analysis.

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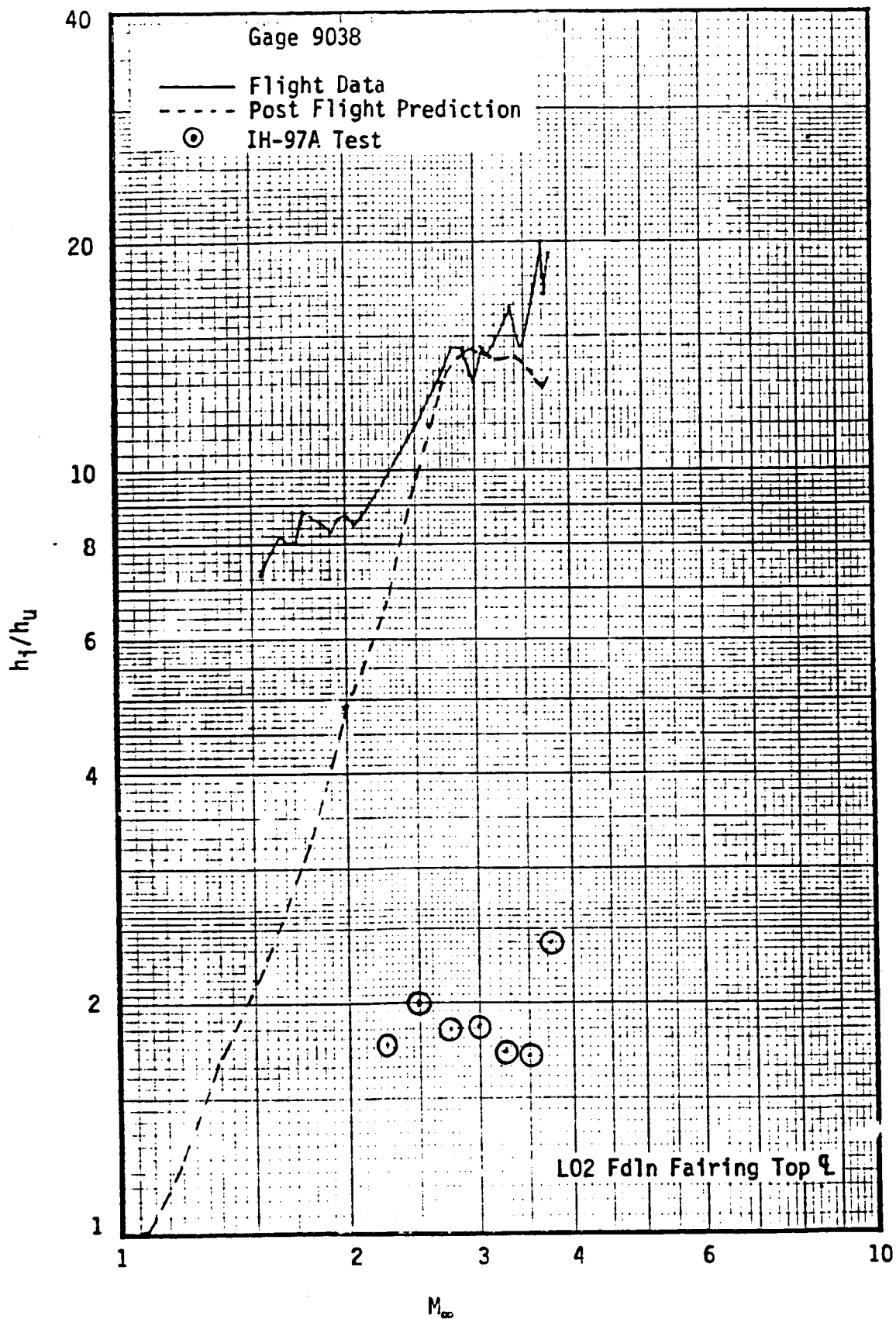
TABLE 1.2 STS-1 ET INTERFERENCE FACTORS FOR PROTUBERANCE POINTS
FROM THE IH-97A WIND TUNNEL DATA BASE

FLIGHT GAGE NO.	IH97A GAGE NO.	HI/HU @ MACH NUMBER						
		2.25	2.50	2.75	3.00	3.25	3.50	3.75
9012	5053	1.135	1.163	1.204	1.225	1.359	1.313	1.190
9038	5054	1.761	2.001	1.847	1.868	1.728	1.716	2.408
9039	5057	—	—	—	—	—	—	—
9040	5055	1.585	1.527	1.945	2.079	2.041	2.105	1.975
9041	5058	10.682	—	14.052	16.421	14.304	19.406	21.470
9042	5059	6.192	—	—	—	—	—	—
9043	5056	2.254	—	—	—	—	—	—
9045	5060	2.546	2.750	2.888	2.915	2.757	2.280	2.217
9046	5061	8.668	8.294	8.068	5.334	4.024	3.294	2.295
9047	5062	2.998	3.420	3.424	3.824	5.989	—	—

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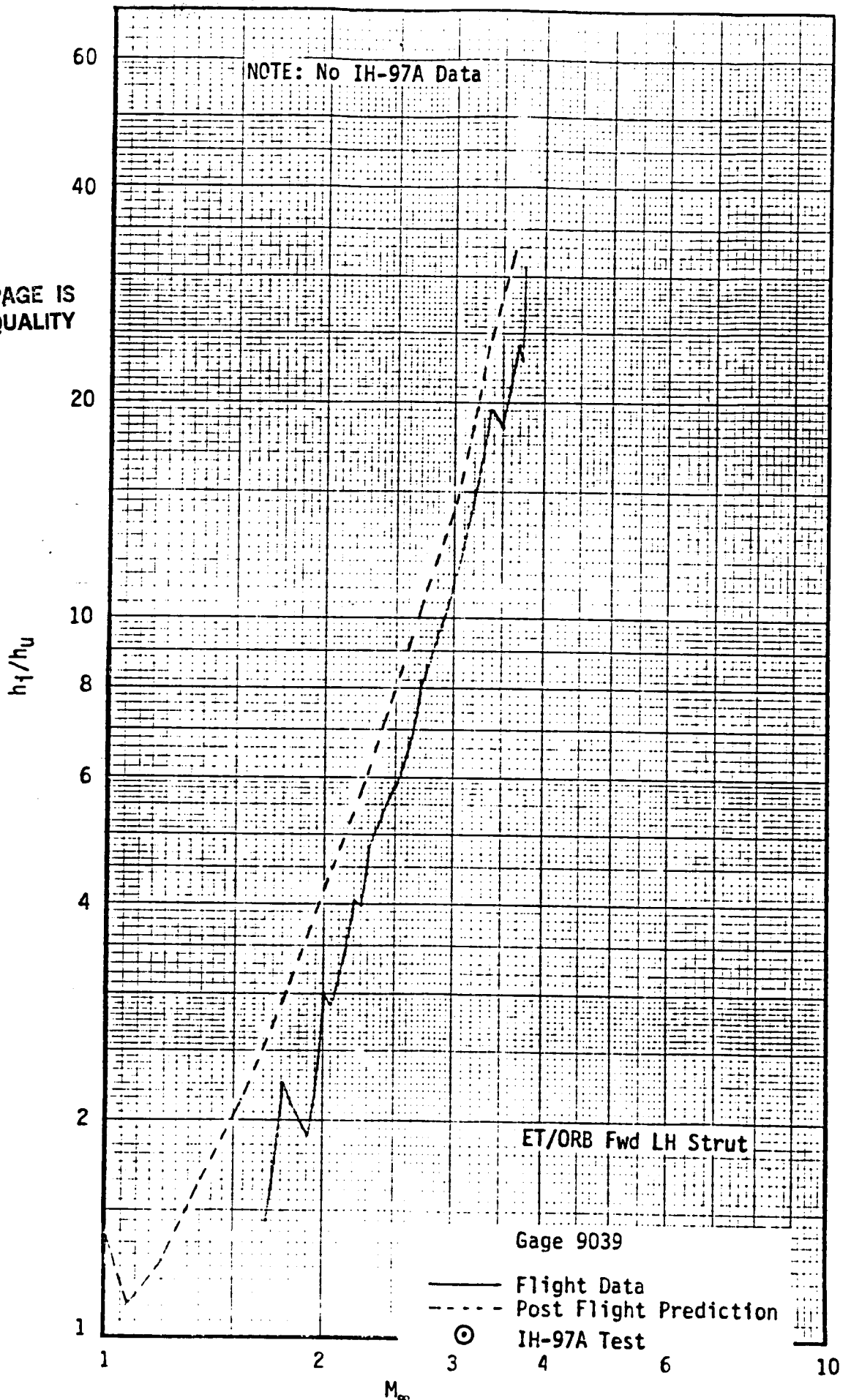


STS-1 Post Flight Interference Factors for Gage 9012



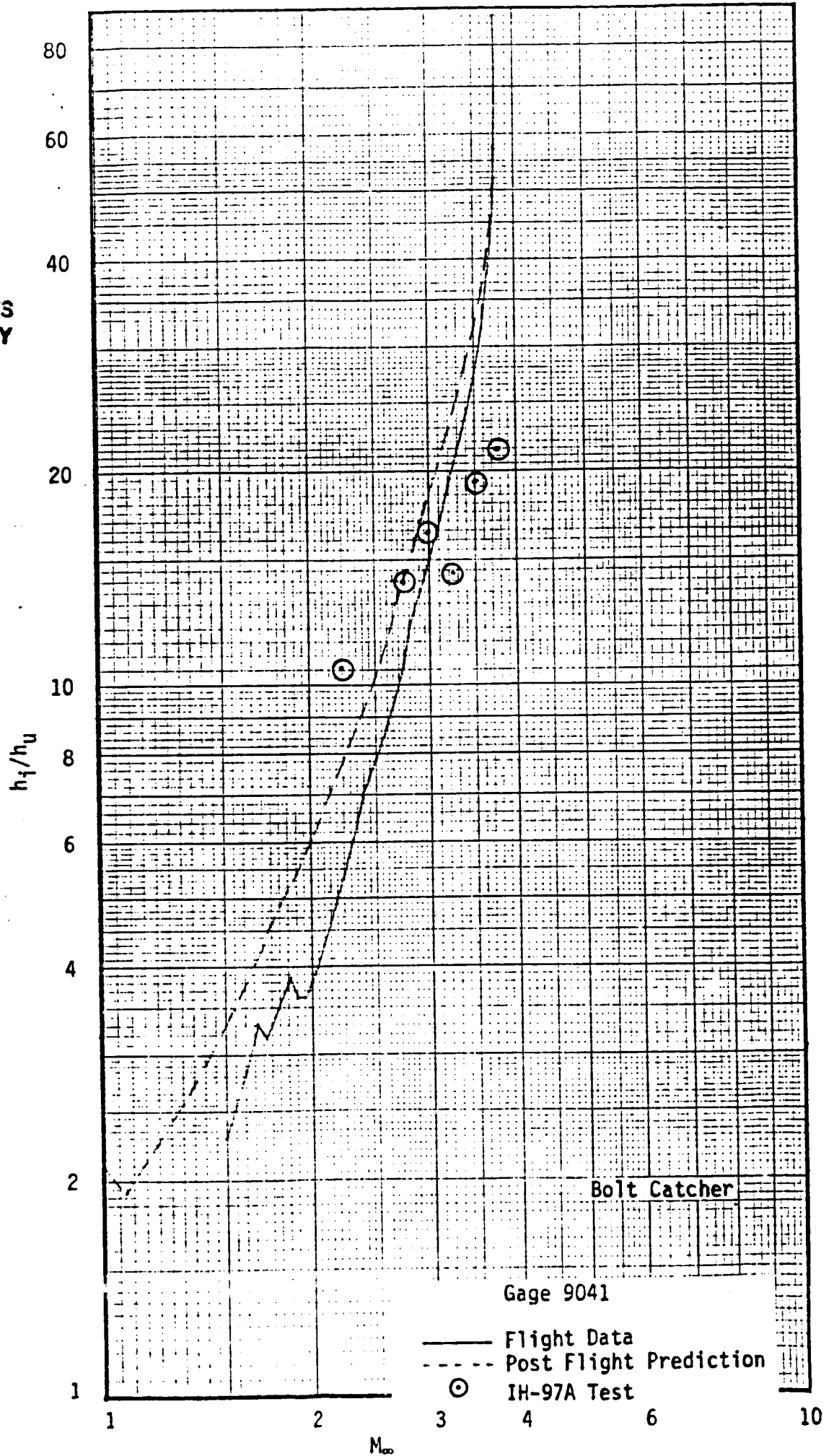
STS-1 Post Flight Interference Factors for Gage 9038

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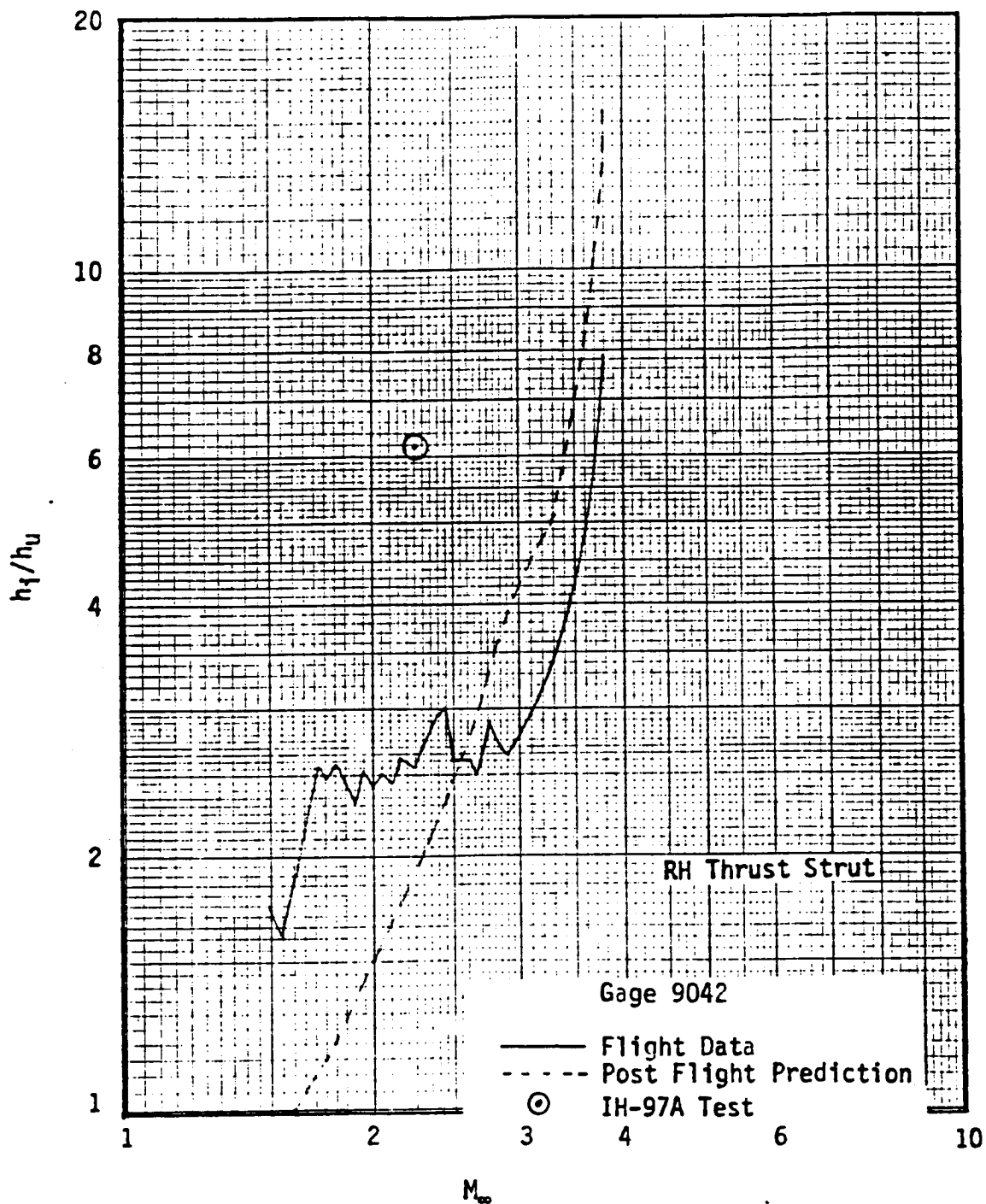
STS-1 Post Flight Interference Factors for Gage 9039

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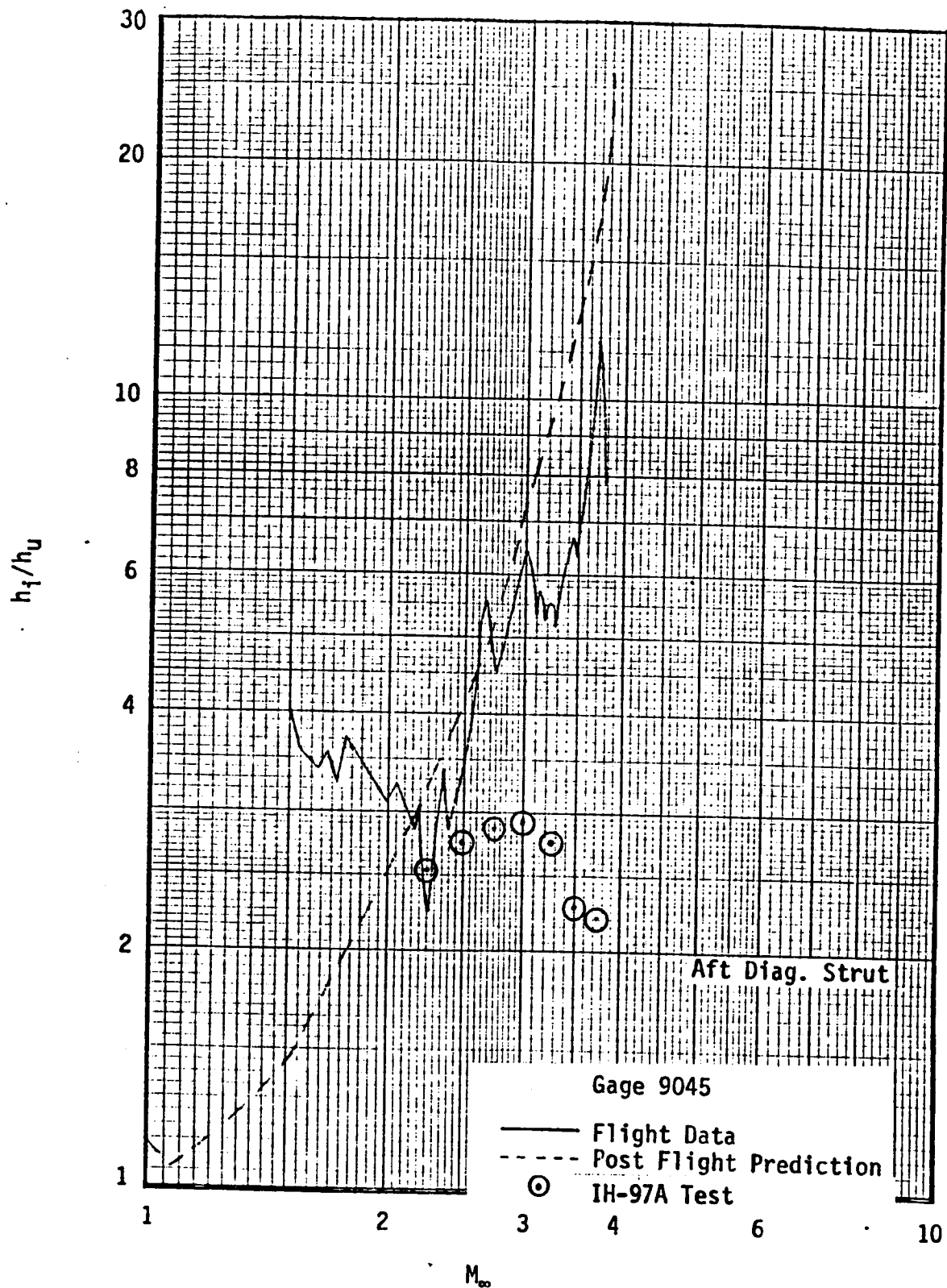


STS-1 Post Flight Interference Factors for Gage 9041

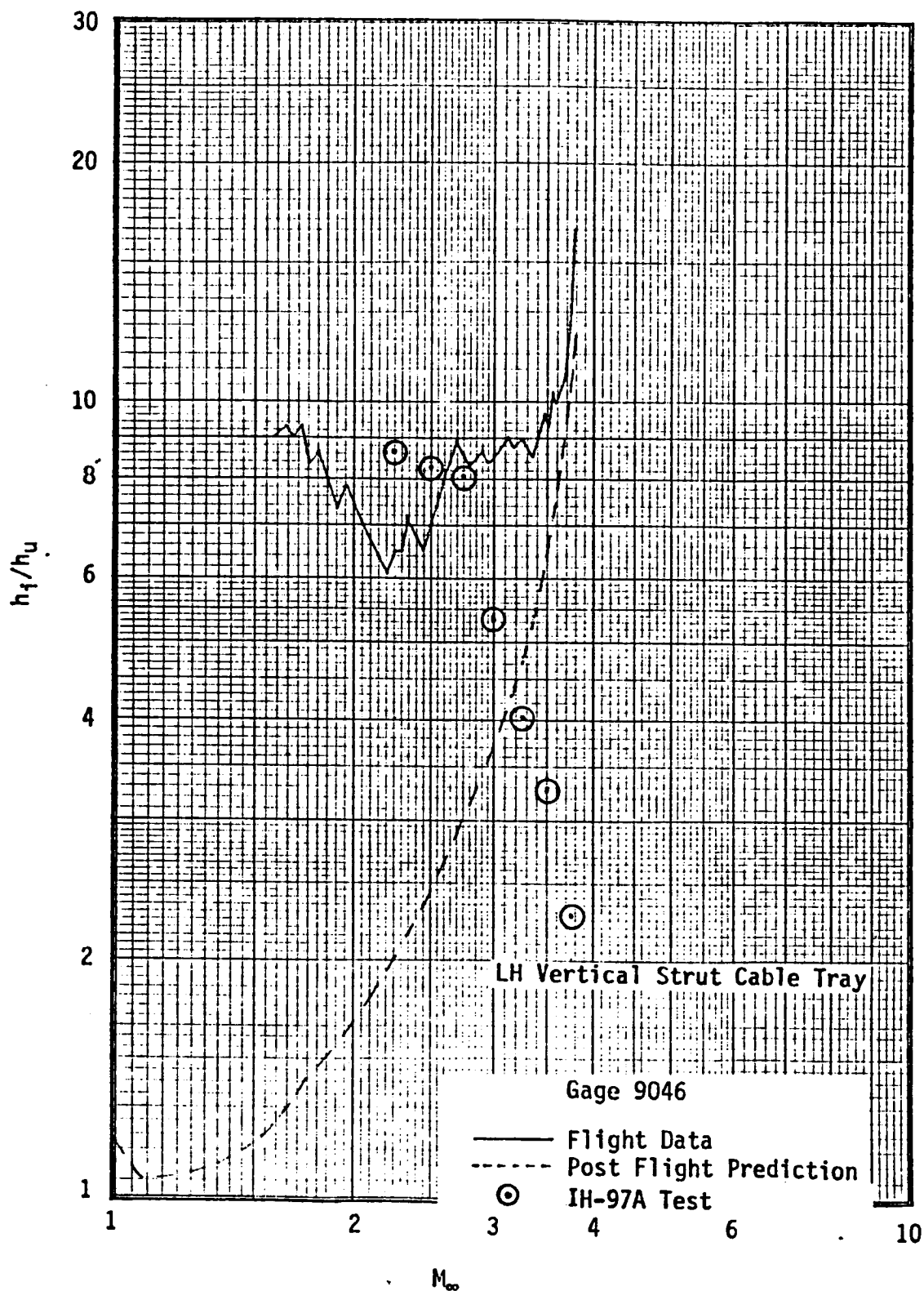
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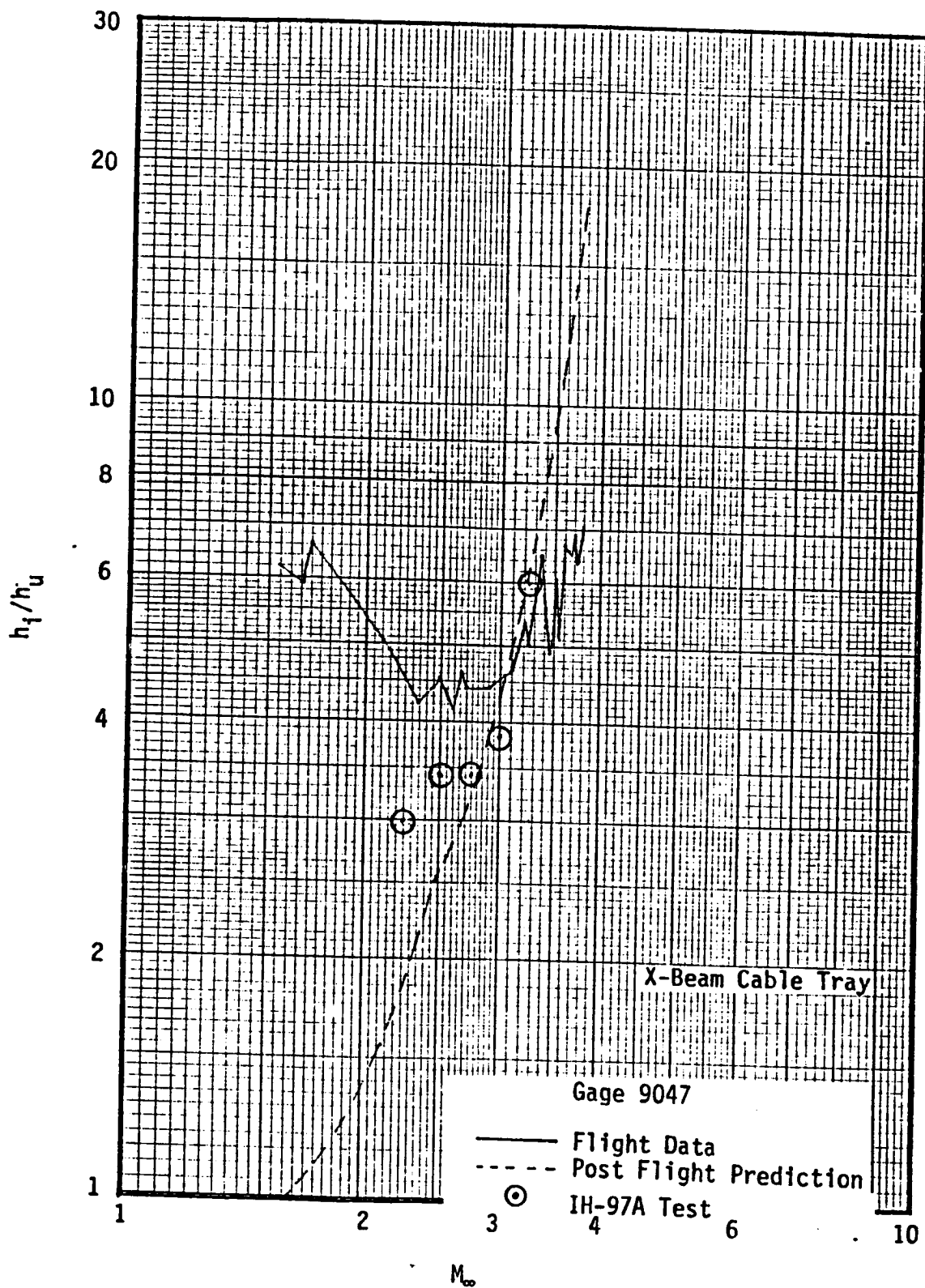
STS-1 Post Flight Interference Factors for Gage 9042



STS-1 Post Flight Interference Factors for Gage 9045



STS-1 Post Flight Interference Factors for Gage 9046



STS-1 Post Flight Interference Factors for Gage 9047

REMTECH INC.

SET-2

STS-2 pp. 2.1 - 2.10

REMTECH INC.

Table 2.1 STS-2 PROTUBERANCE DFI LOCATIONS

MEASUREMENT I.D.	XT (IN.)	THETA (DEG.)	GAGE TYPE	LOCATION
T07R9012A	1008.0	21.0	Ind. Gage	L02 Fdln. Fairing (side)
T07R9038A	996.0	23.0	Ind. Gage	L02 Fdln. Fairing (top)
T07R9039A	1129.9	356.0	Ind. Gage	ET/ORB Fwd LH Strut
T07R9041A	959.2	270.0	Ind. Gage	Bolt Catcher
T07R9042A	2002.0	29.0	Ind. Gage	RH Thrust Strut
T07R9045A	2058.0	10.0	Ind. Gage	Aft Diag. Strut
T07R9046A	2054.0	45.0	Ind. Gage	LH Vert Strut Cable Tray
T07R9047A	2030.0	26.0	Ind. Gage	Fwd. L02 Fdln/X-Beam Cable Tray

REMTECH INC.

TABLE 2.2 STS-2 ET INTERFERENCE FACTORS FOR PROTUBERANCE POINTS
FROM THE IH-97A WIND TUNNEL DATA BASE

FLIGHT GAGE NO.	IH97A GAGE NO.	HI/HU @ MACH NUMBER						
		2.25	2.50	2.75	3.00	3.25	3.50	3.75
9012	5053	1.295	1.116	1.697	1.301	0.930	0.759	0.950
9038	5054	3.937	4.002	6.988	8.358	6.781	8.468	5.702
9039	5057	—	—	—	—	—	—	—
9040	5055	1.815	1.477	1.666	1.769	1.438	1.183	1.934
9041	5058	10.123	12.633	14.742	18.618	17.613	22.212	25.560
9042	5059	—	—	—	—	—	—	—
9043	5056	1.322	—	—	—	—	—	—
9045	5060	2.981	3.507	4.001	3.826	3.504	3.191	2.937
9046	5061	5.340	5.721	4.376	3.973	2.773	3.164	2.332
9047	5062	5.311	5.907	7.103	7.065	7.911	—	—

STS-2 ET FLT (—), RATE1 FRED (---), & IH97-A (O) - GAGE 9012, ISLAND XXX
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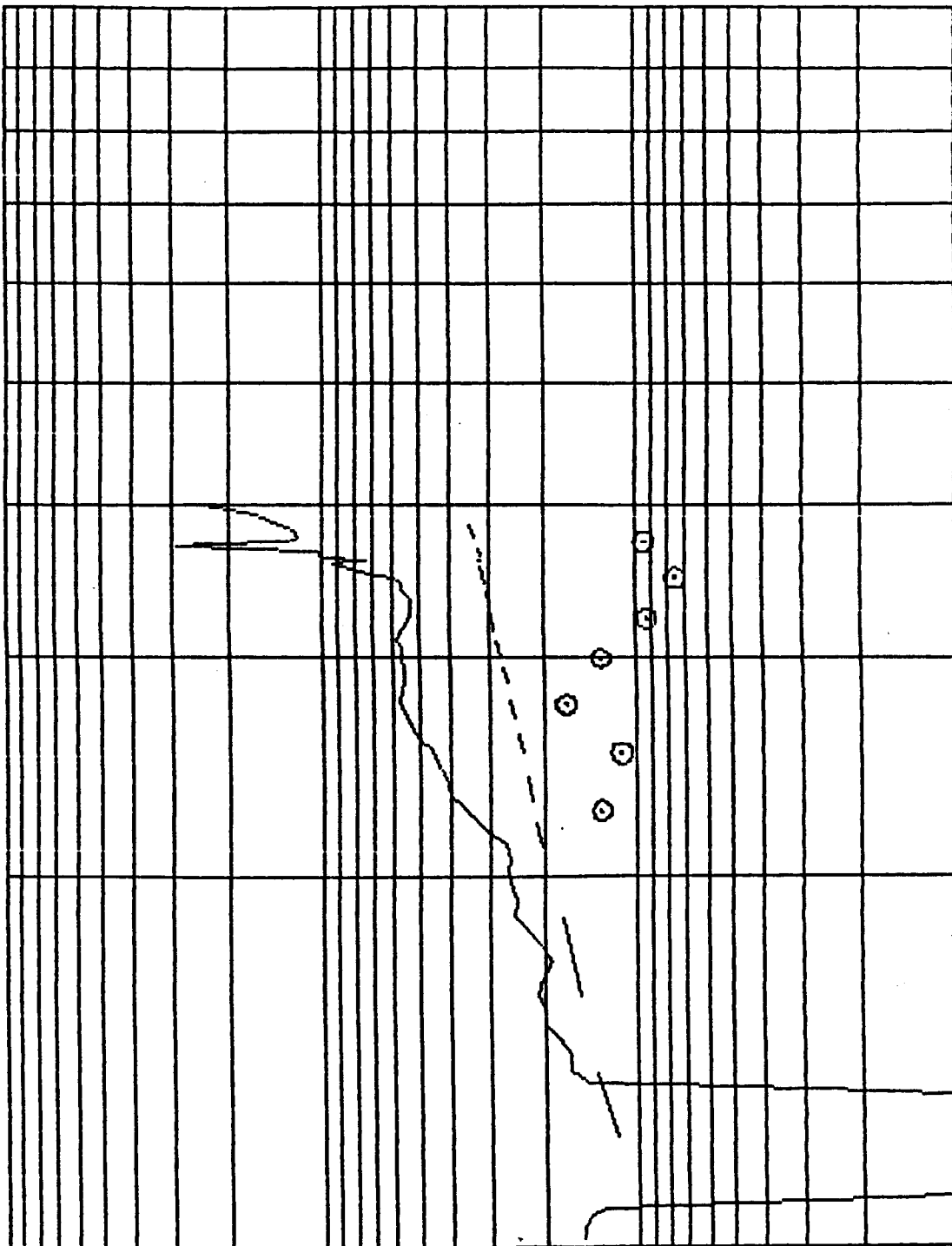
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1. 2. 4. 6. 8. 10. MACH NUMBER



STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9038, ISLAND XXX
100.

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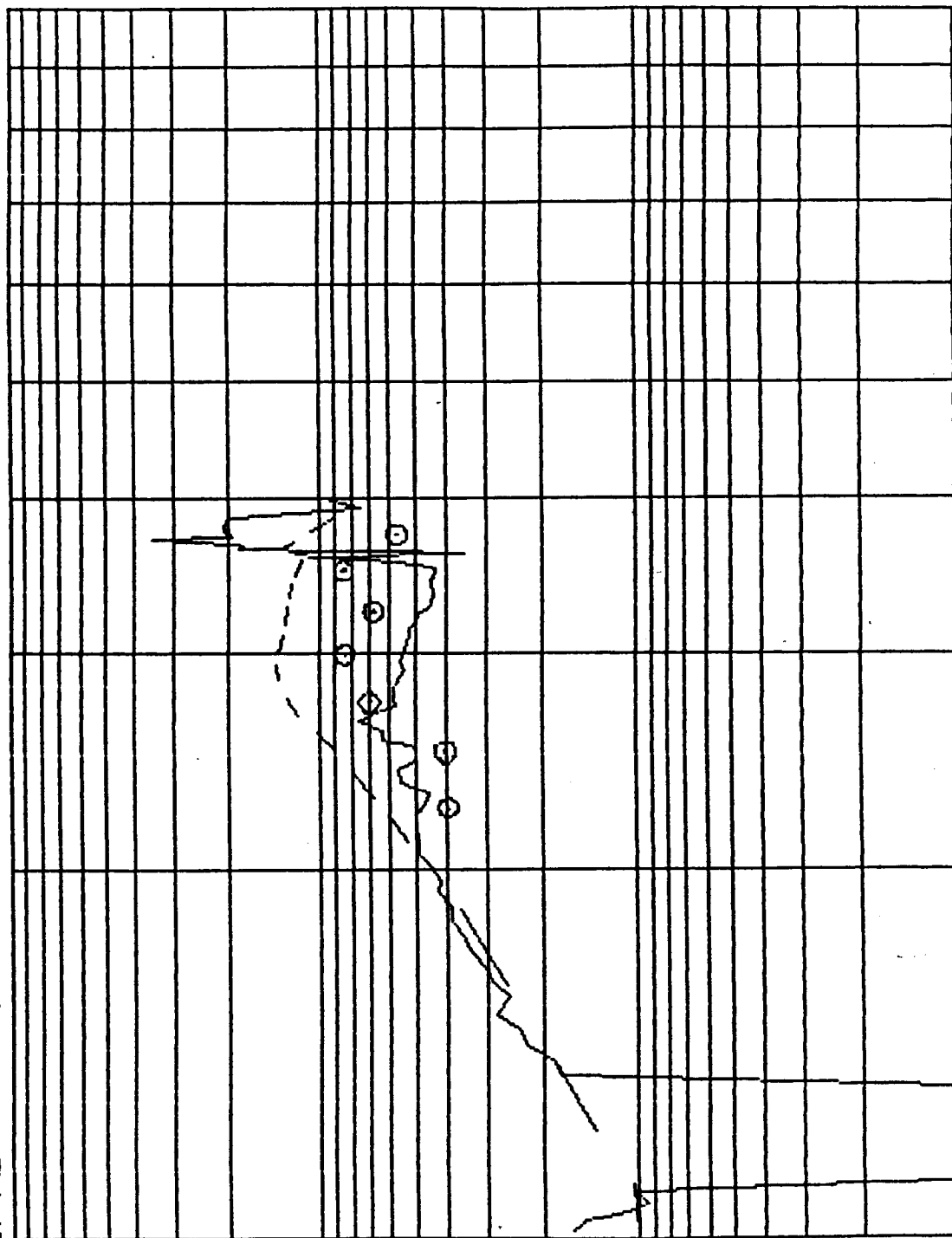
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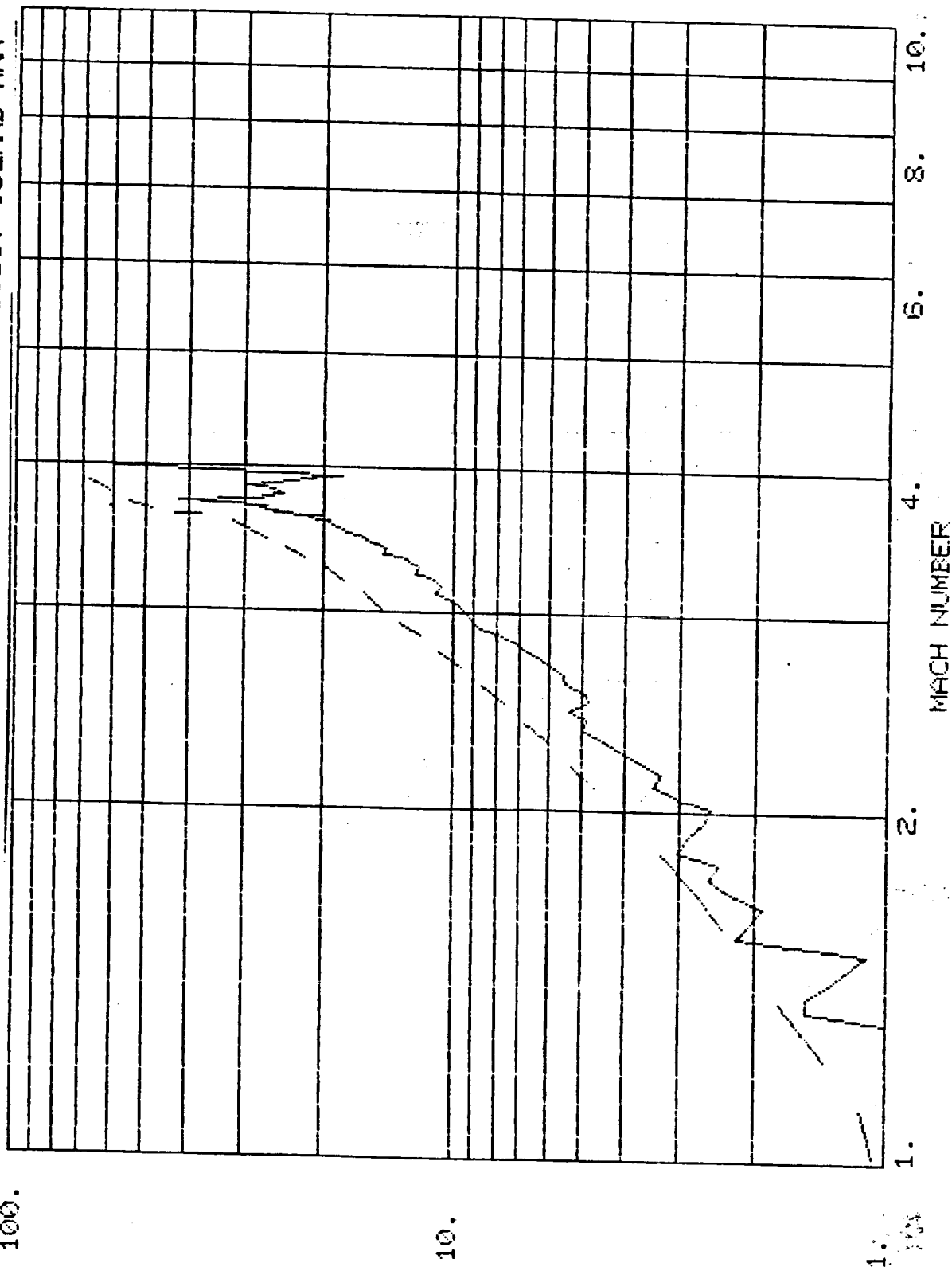
MACH NUMBER

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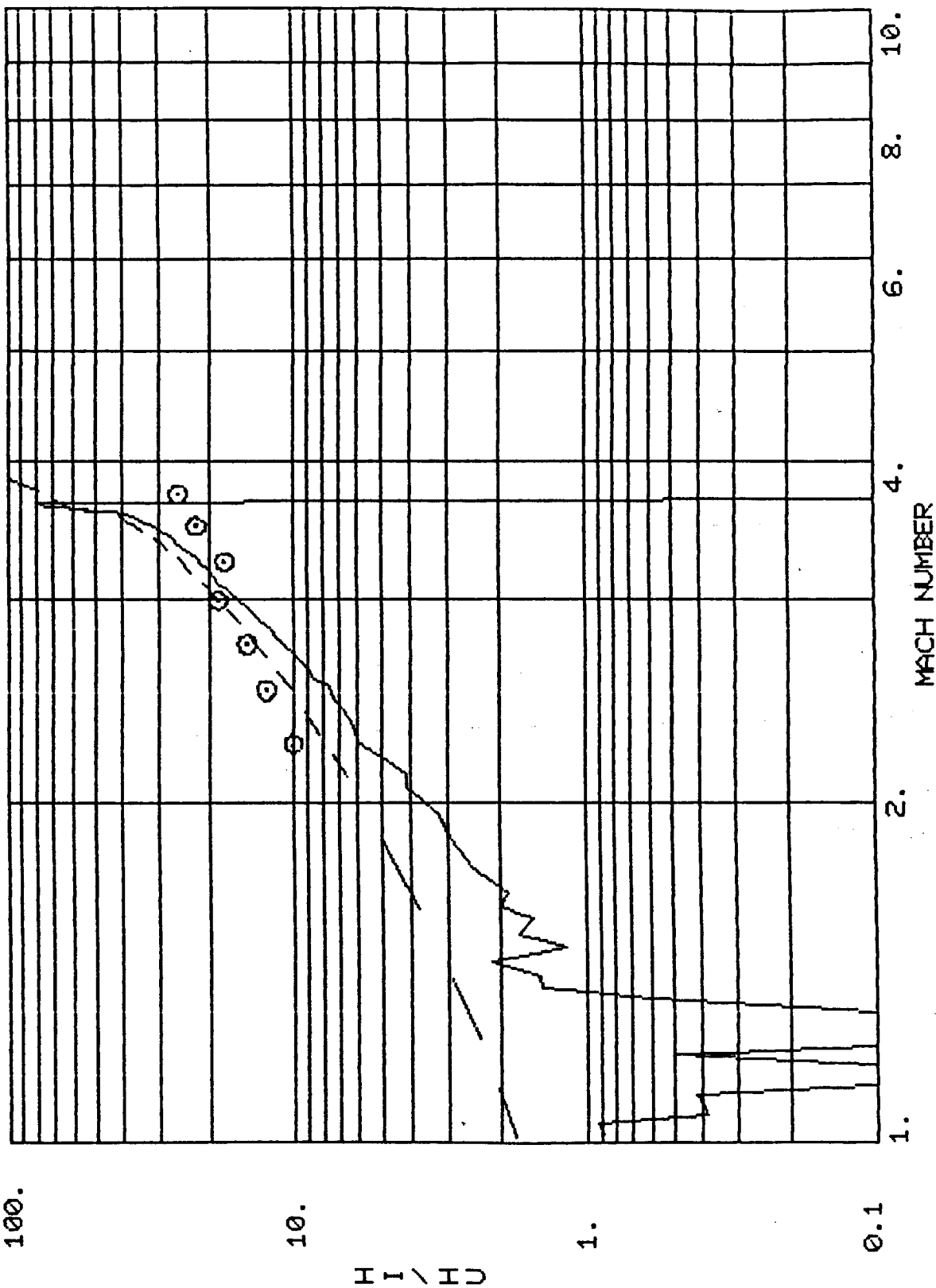
STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9039, ISLAND XXX
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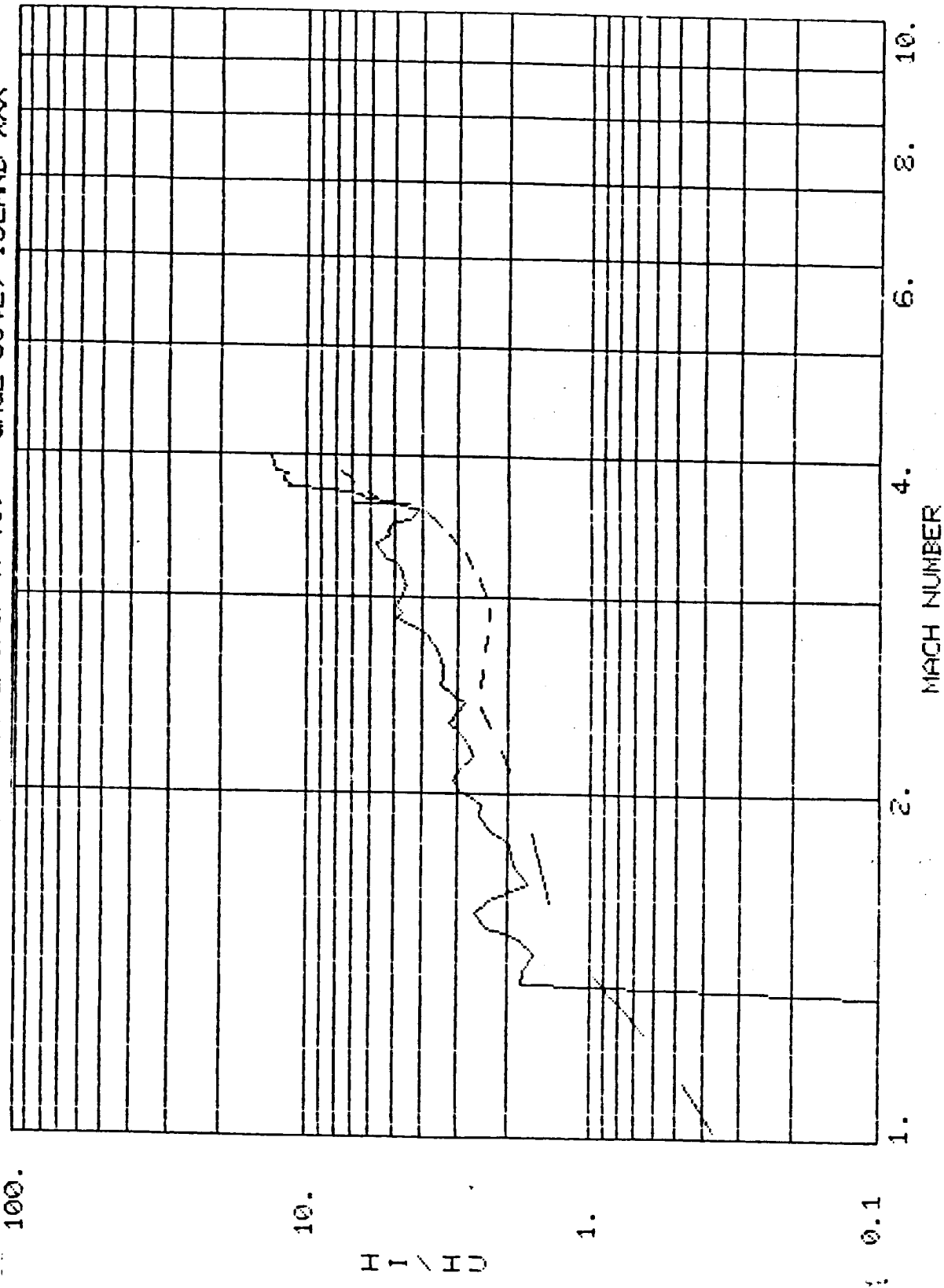


NOTE: No IH-97A Data

STS-2 ET FLT (→), RATE1 PRED (←→), & IH97-A (○) - GAGE 9041, ISLAND XXX
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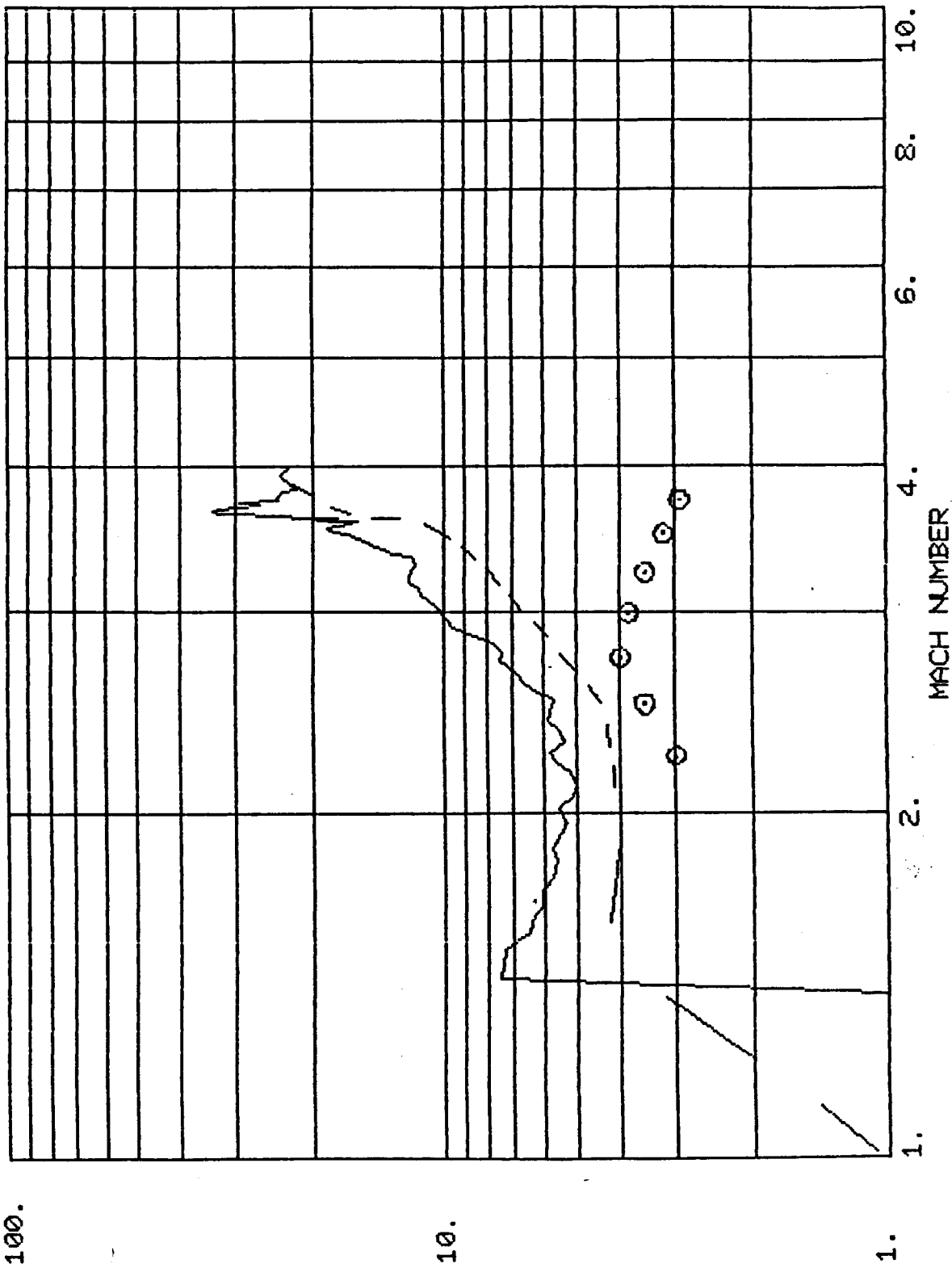
STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9042, ISLAND XXX



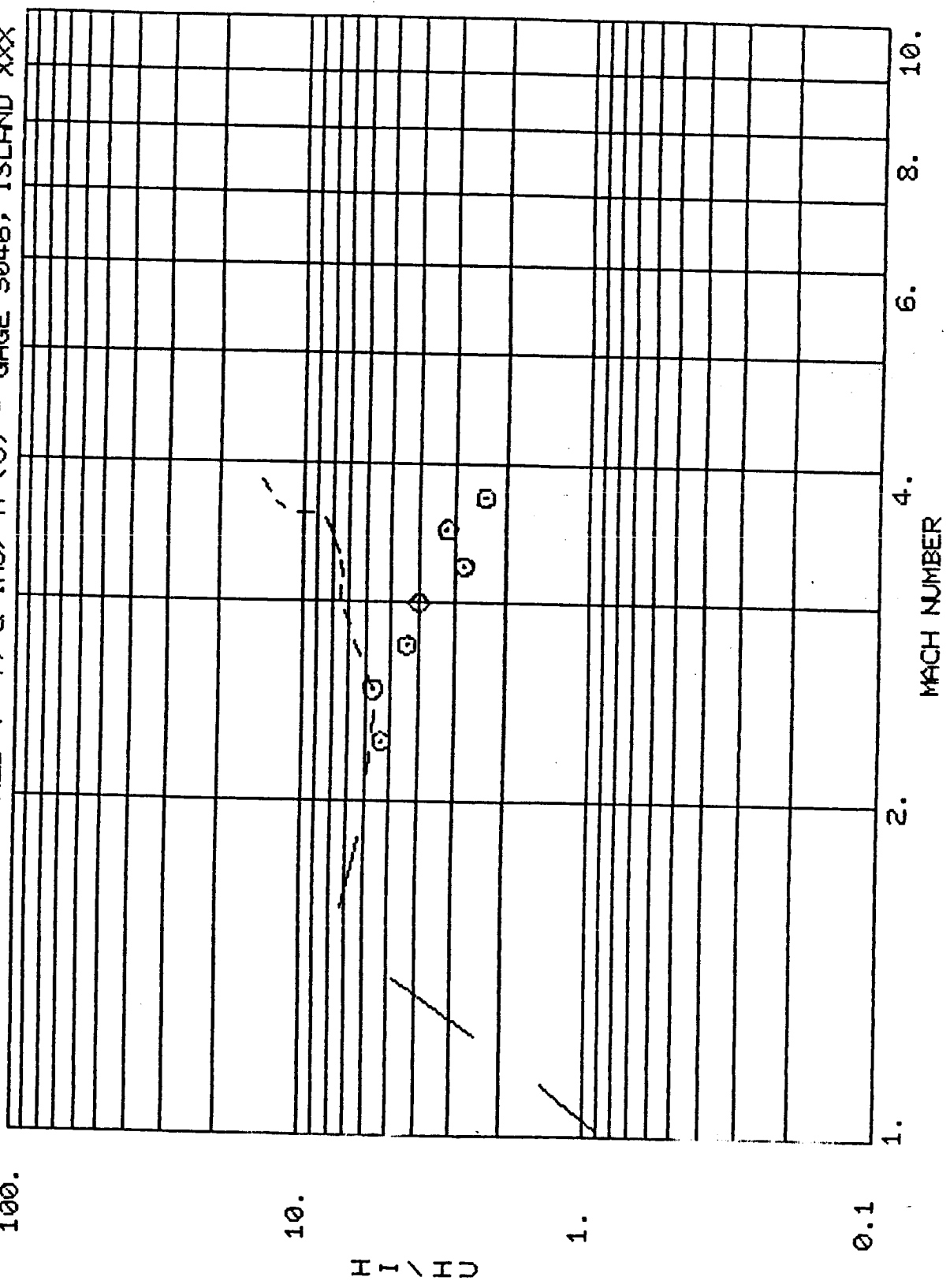
NOTE: No IH-97A Data

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9045, ISLAND XXX
100.

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STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9046, ISLAND XXX
100.



NOTE: Bad Flight Data

STS-2 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9047, ISLAND XXX
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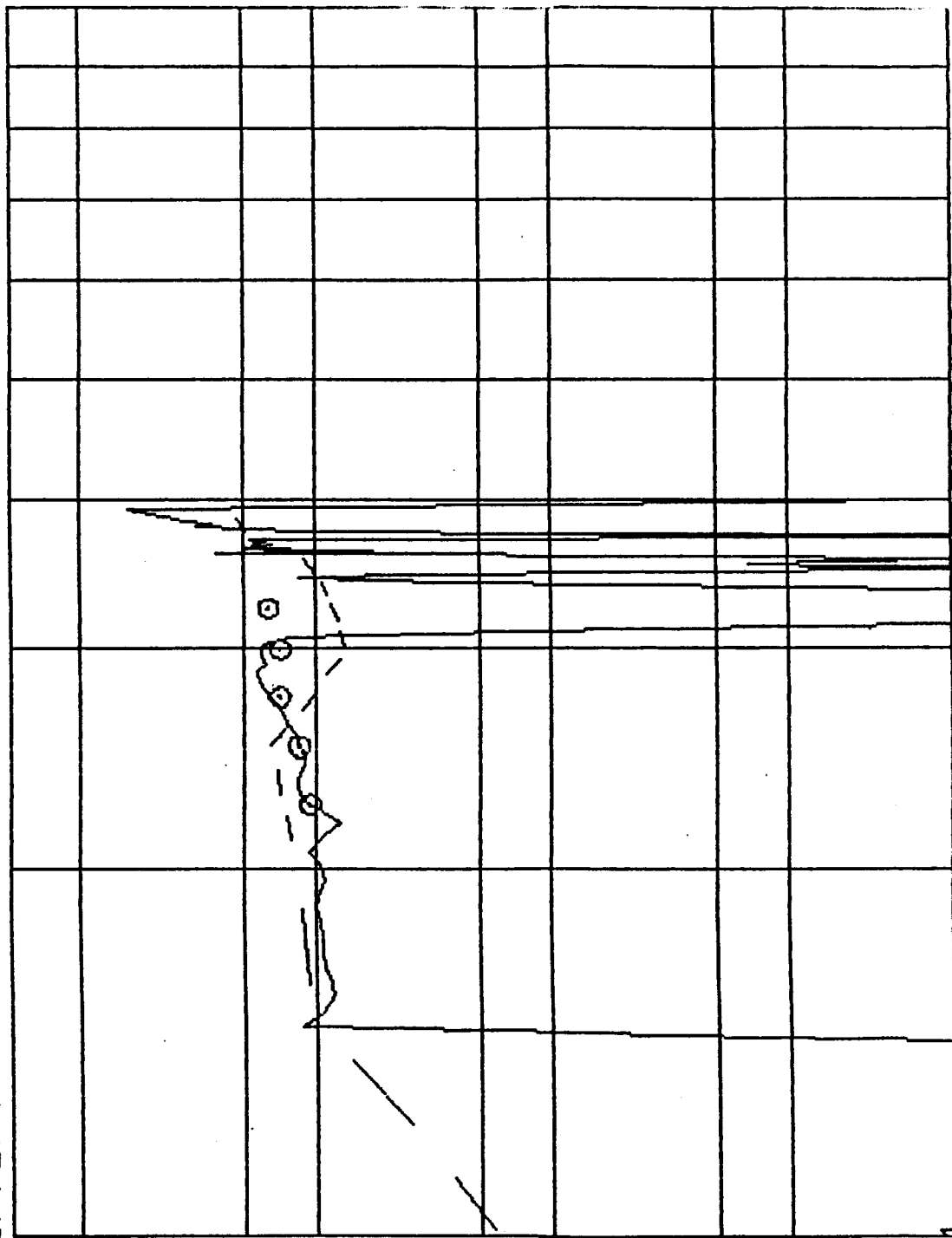
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MACH NUMBER
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REMTECH INC.

SET-3

STS-2 pp. 3.1 - 3.10

REMTECH INC.

Table 3.1 STS-3 PROTUBERANCE DFI LOCATIONS

MEASUREMENT I.D.	XT (IN.)	THETA (DEG.)	GAGE TYPE	LOCATION
T07R9012A	1008.0	21.0	Ind. Gage	L02 FdIn. Fairing (side)
T07R9038A	996.0	23.0	Ind. Gage	L02 FdIn Fairing (top)
T07R9039A	1129.9	356.0	Ind. Gage	ET/ORB Fwd LH Strut
T07R9041A	959.2	270.0	Ind. Gage	Bolt Catcher
T07R9042A	2002.0	29.0	Ind. Gage	RH Thrust Strut
T07R9045A	2058.0	10.0	Ind. Gage	Aft Diag. Strut
T07R9046A	2054.0	45.0	Ind. Gage	LH Vert Strut Cable Tray
T07R9047A	2030.0	26.0	Ind. Gage	Fwd. L02 FdIn/X-Beam Cable Tray

REMTECH INC.

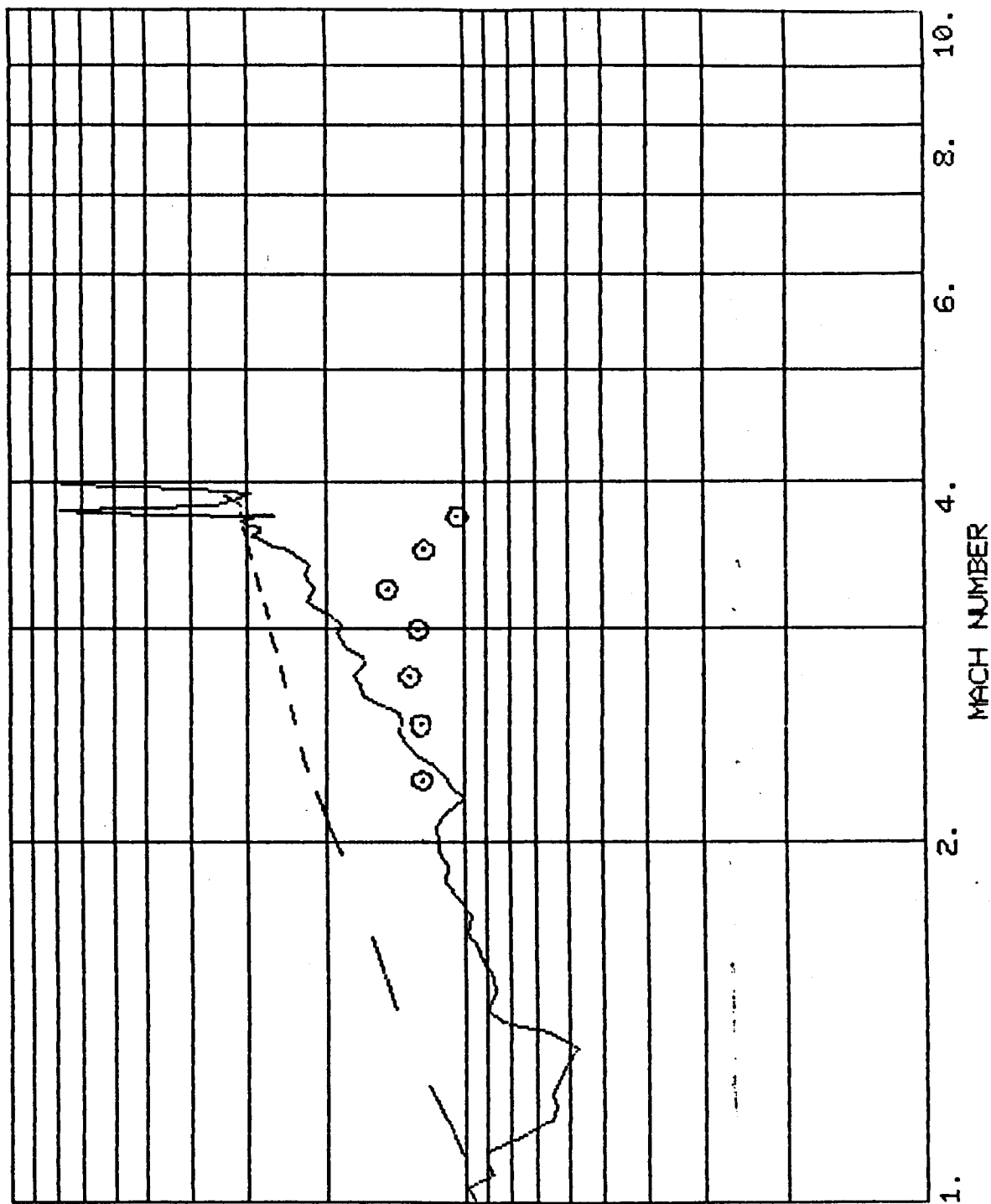
TABLE 3.2 STS-3 ET INTERFERENCE FACTORS FOR PROTUBERANCE POINTS
FROM THE IH-97A WIND TUNNEL DATA BASE

FLIGHT GAGE NO.	IH97A GAGE NO.	HI/HU @ MACH NUMBER						
		2.25	2.50	2.75	3.00	3.25	3.50	3.75
9012	5053	1.233	1.243	1.313	1.260	1.467	1.222	1.034
9038	5054	1.640	1.232	1.239	1.219	1.207	4.383	4.495
9039	5057	—	—	—	—	—	—	—
9040	5055	1.409	1.394	1.586	1.796	1.774	2.168	2.044
9041	5058	10.373	12.418	14.843	17.594	19.888	25.222	26.458
9042	5059	—	—	—	—	—	—	—
9043	5056	1.885	—	—	—	—	—	—
9045	5060	2.801	2.719	2.904	2.812	2.778	2.392	2.397
9046	5061	7.764	9.618	9.491	4.734	4.863	2.361	2.572
9047	5062	3.284	3.958	4.185	5.286	10.009	—	—

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9012, ISLAND XXX
10.

H I / HU
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STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9038, ISLAND XXX
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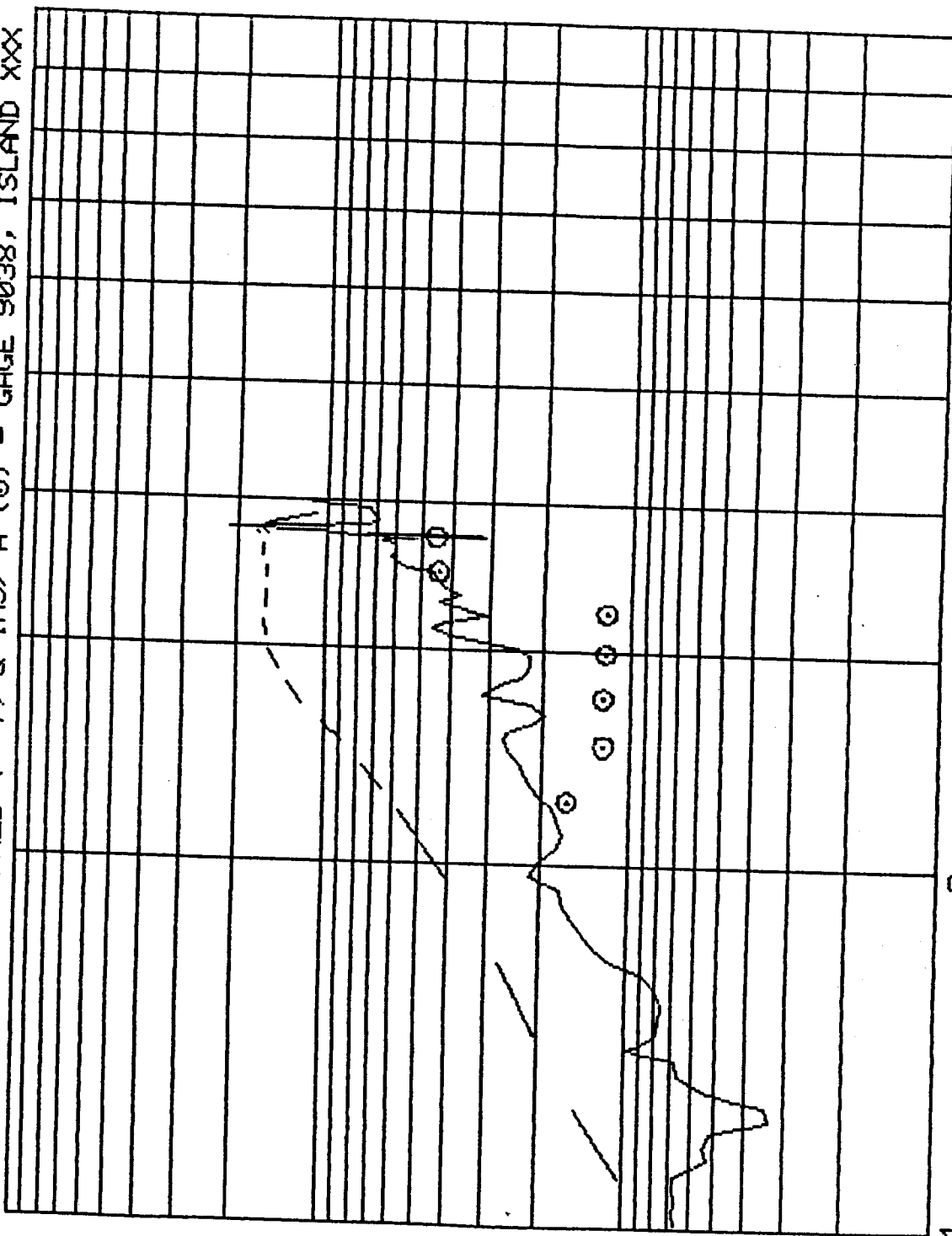
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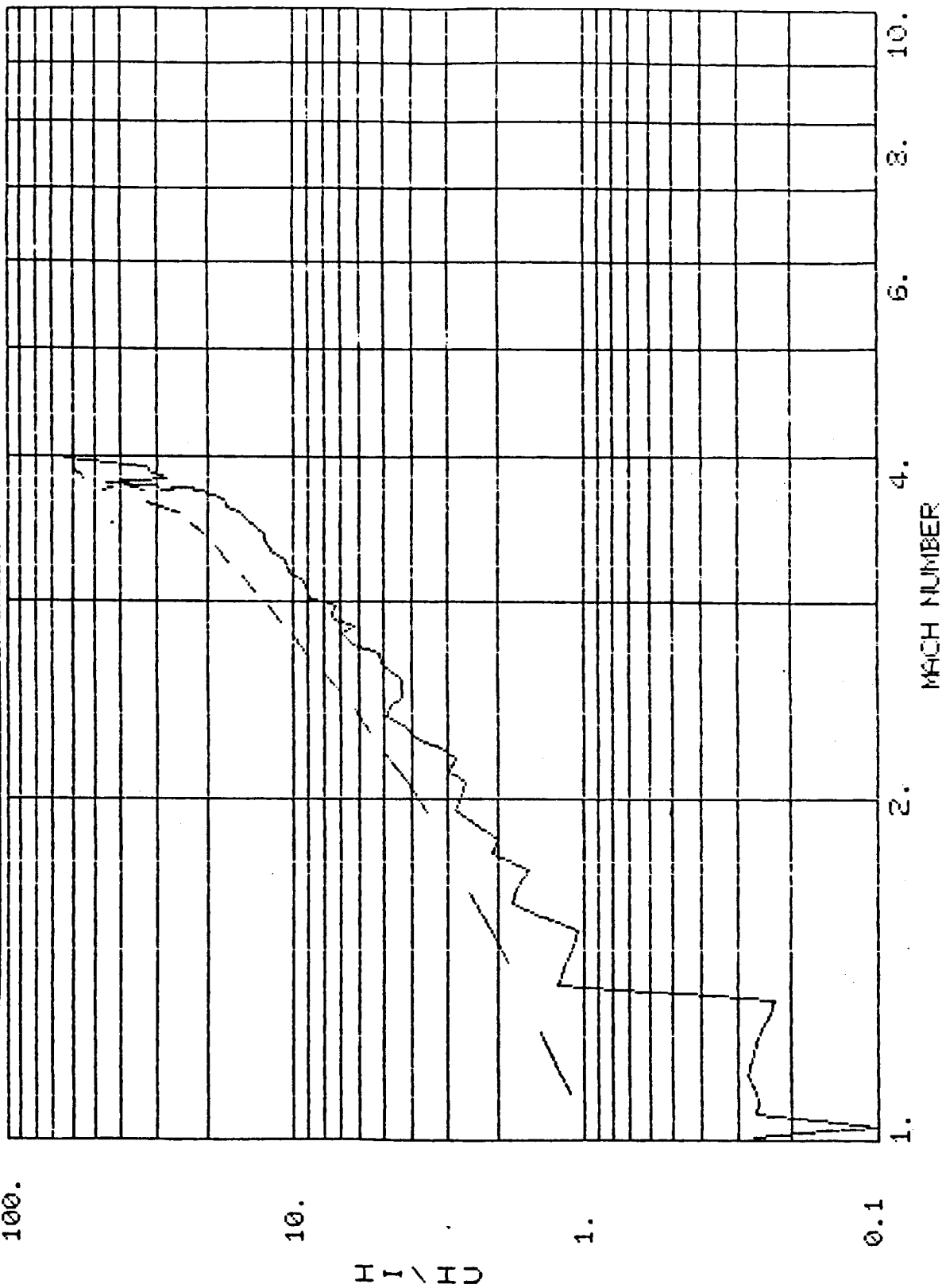
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MACH NUMBER

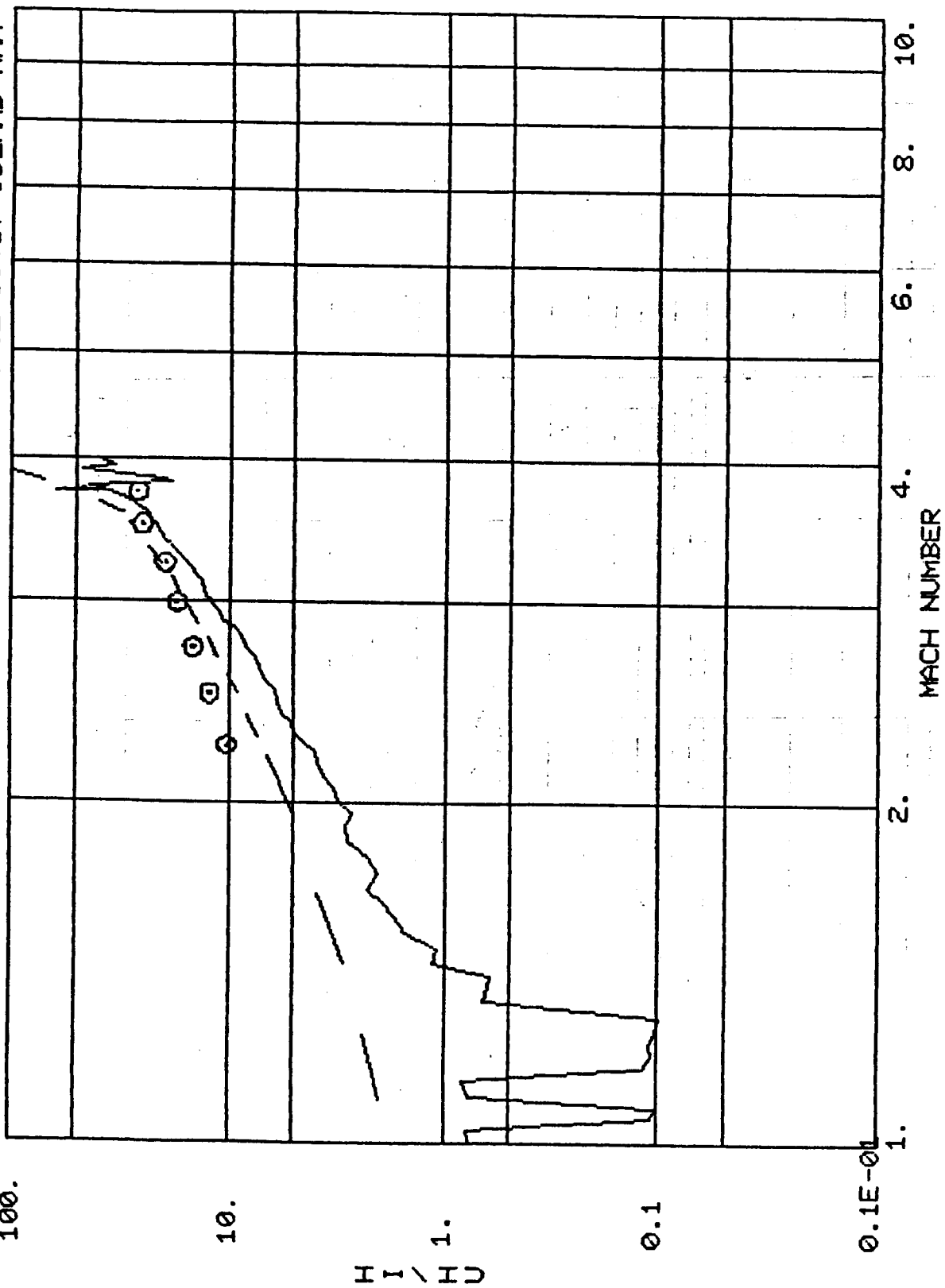


STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (o) - GAGE 9039, ISLAND XXX

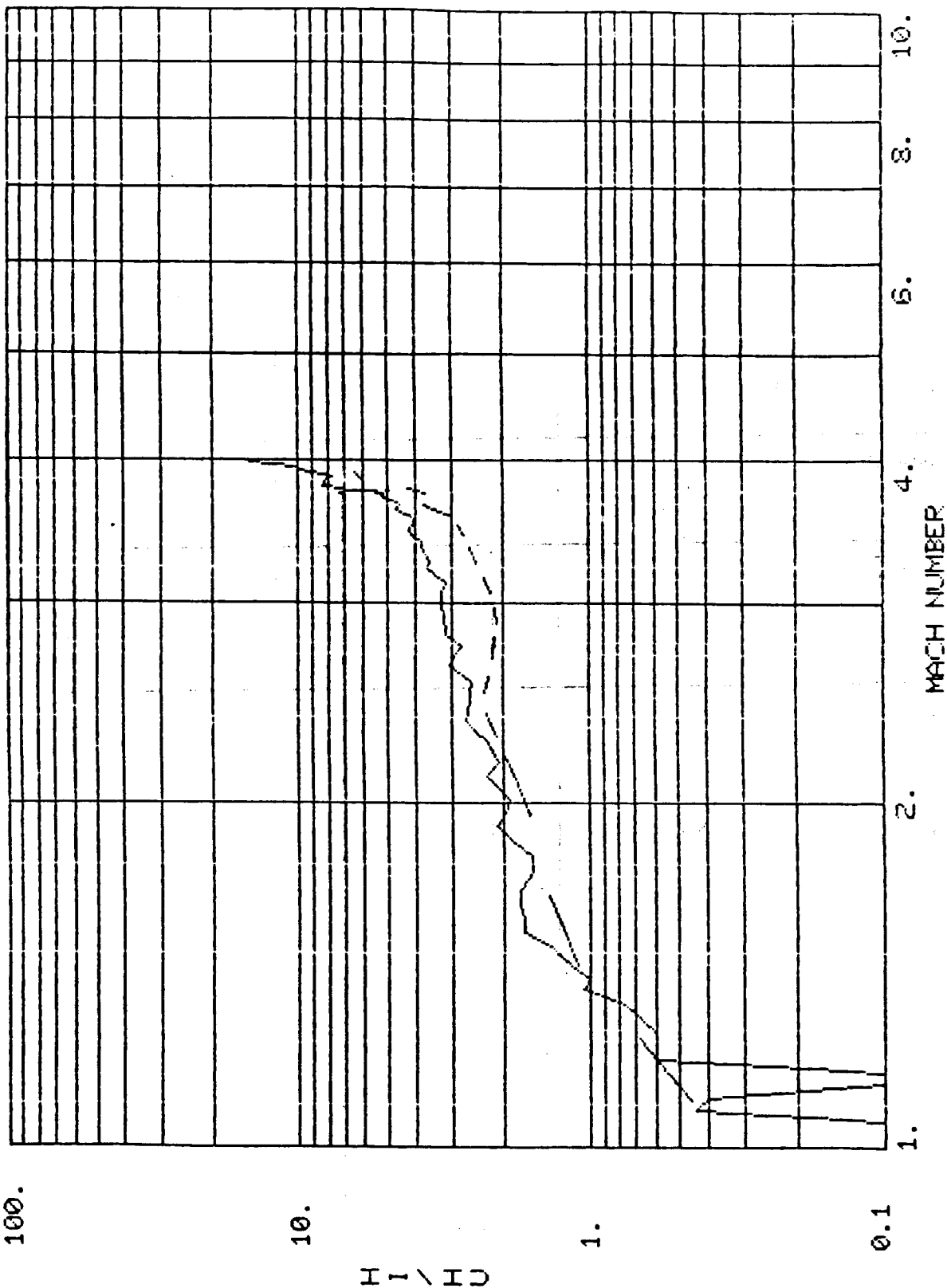


NOTE: No IH-97A Data

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9041, ISLAND XXX
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STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9042, ISLAND XXX
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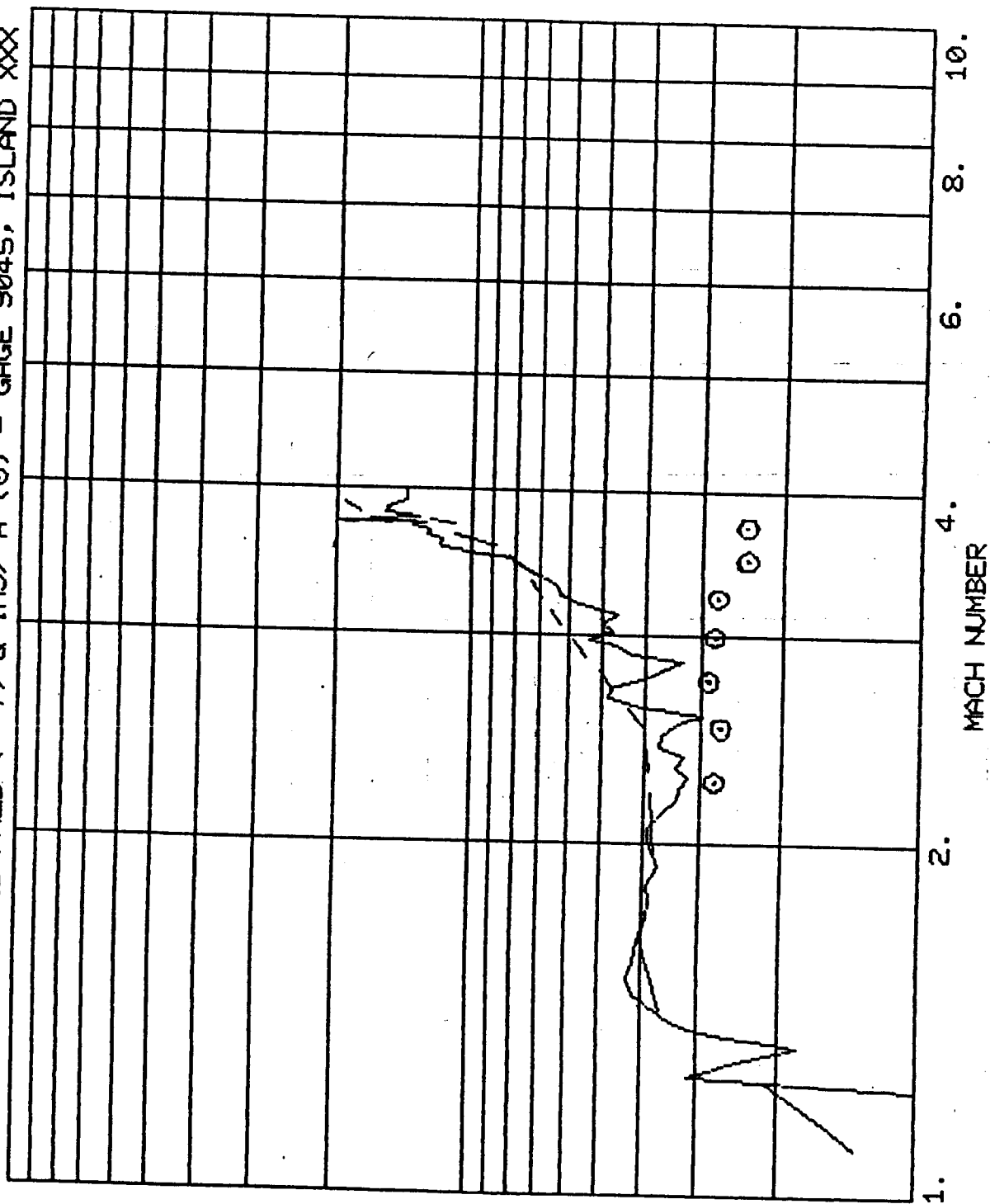


NOTE: No IH-97A Data

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9045, ISLAND XXX
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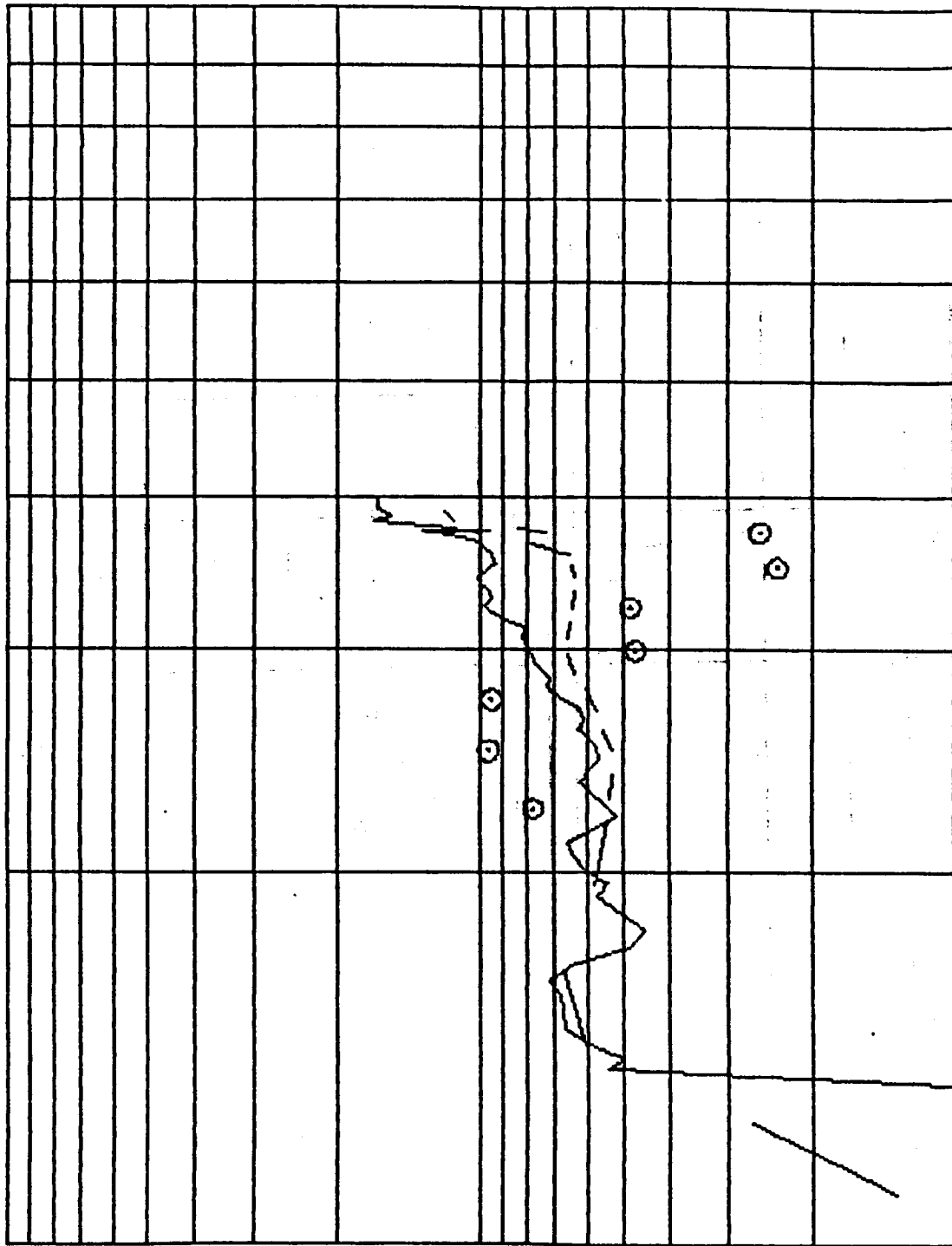


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STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9046, ISLAND XXX
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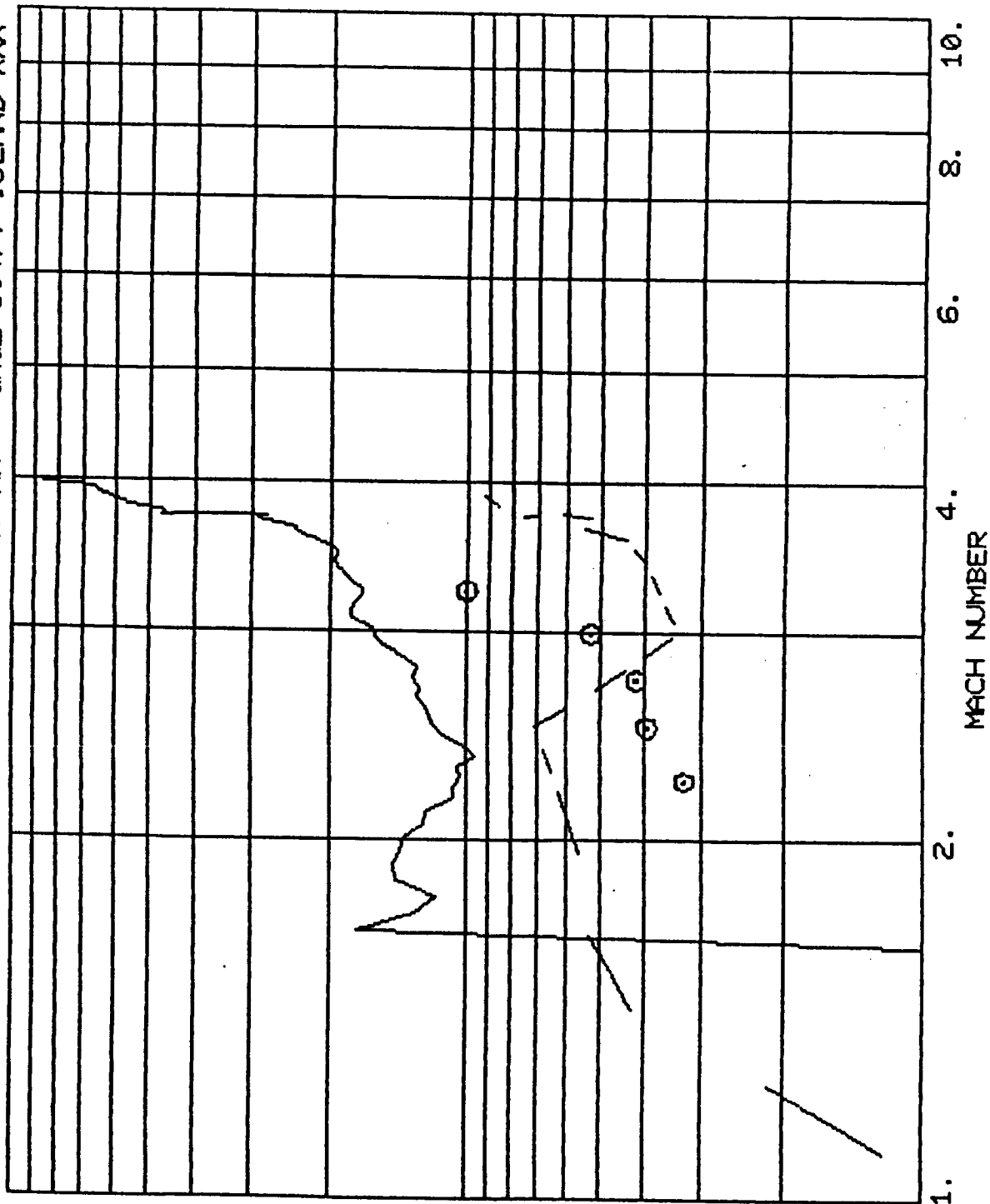


1. 2. 4. 6. 8. 10. MACH NUMBER

STS-3 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9047, ISLAND XXX
100.

H I / H U
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REMTECH INC.

SET-4

STS-4 pp. 4.1 - 4.10

REMTECH INC.

Table 4.1 STS-4 PROTUBERANCE DFI LOCATIONS

MEASUREMENT I.D.	XT (IN.)	THETA (DEG.)	GAGE TYPE	LOCATION
T07R9012A	1008.0	21.0	Ind. Gage	L02 Fdln. Fairing (side)
T07R9038A	996.0	23.0	Ind. Gage	L02 Fdln. Fairing (top)
T07R9039A	1129.9	356.0	Ind. Gage	ET/ORB Fwd LH Strut
T07R9041A	959.2	270.0	Ind. Gage	Bolt Catcher
T07R9042A	2002.0	29.0	Ind. Gage	RH Thrust Strut
T07R9045A	2058.0	10.0	Ind. Gage	Aft Diag. Strut
T07R9046A	2054.0	45.0	Ind. Gage	LH Vert Strut Cable Tray
T07R9047A	2030.0	26.0	Ind. Gage	Fwd. L02 Fdln/X-Beam Cable Tray

REMTECH INC.

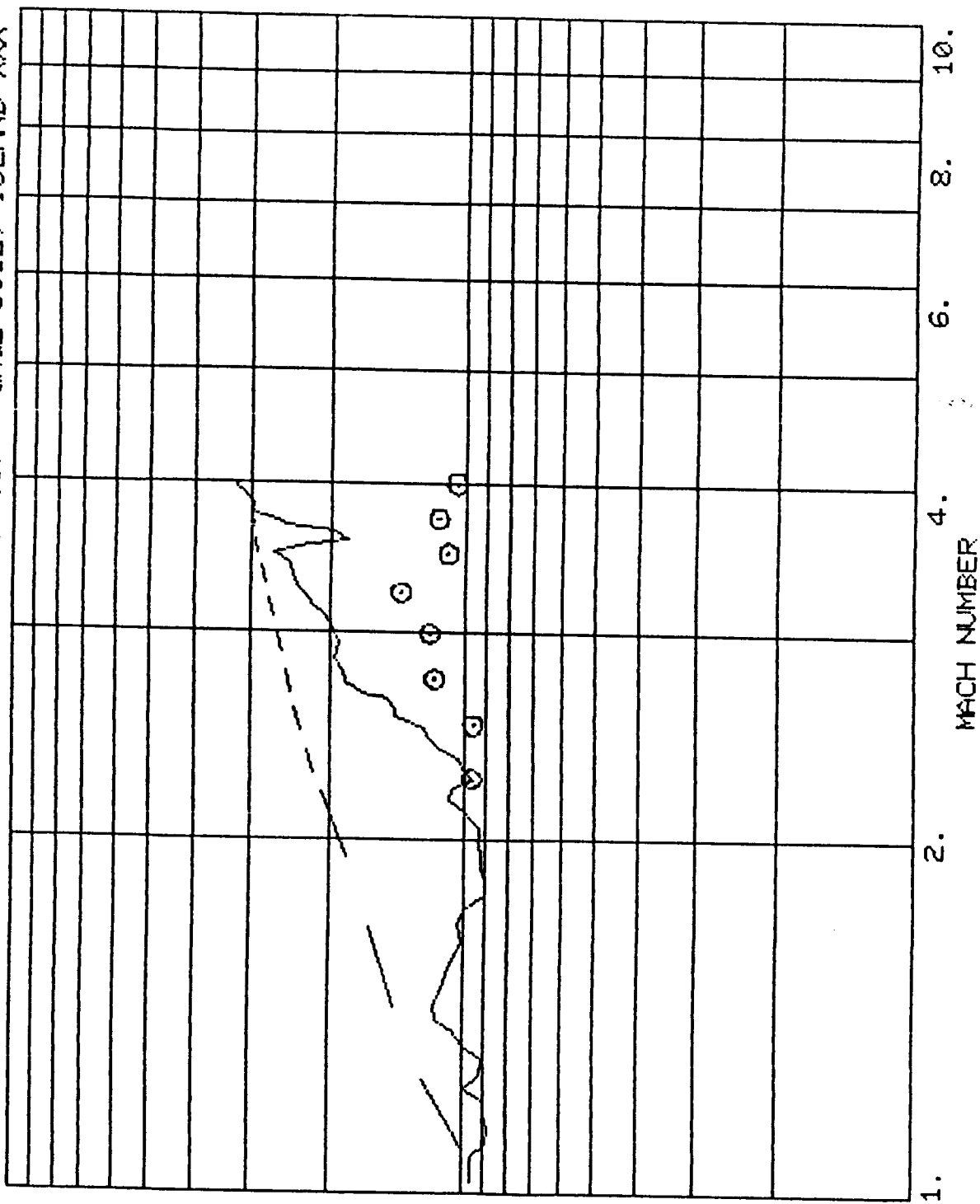
TABLE 4.2 STS-4 ET INTERFERENCE FACTORS FOR PROTUBERANCE POINTS
FROM THE IH-97A WIND TUNNEL DATA BASE

FLIGHT GAGE NO.	IH97A GAGE NO.	HI/HU @ MACH NUMBER							
		2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
9012	5053	0.968	0.960	1.167	1.199	1.386	1.092	1.150	1.047
9038	5054	2.482	2.245	1.712	2.416	2.689	4.722	4.829	4.601
9039	5057	—	—	—	—	—	—	—	—
9040	5055	1.658	1.715	1.496	1.850	1.919	2.115	2.228	2.184
9041	5058	9.733	12.339	14.908	18.829	21.685	25.807	27.188	30.823
9042	5059	—	—	—	—	—	—	—	—
9043	5056	1.183	—	—	—	—	—	—	—
9045	5060	2.698	2.738	—	3.397	1.828	2.316	2.611	3.655
9046	5061	5.500	4.290	3.150	4.039	2.113	2.162	10.982	4.627
9047	5062	3.444	4.967	5.439	7.759	—	—	—	—

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9012, ISLAND XXX
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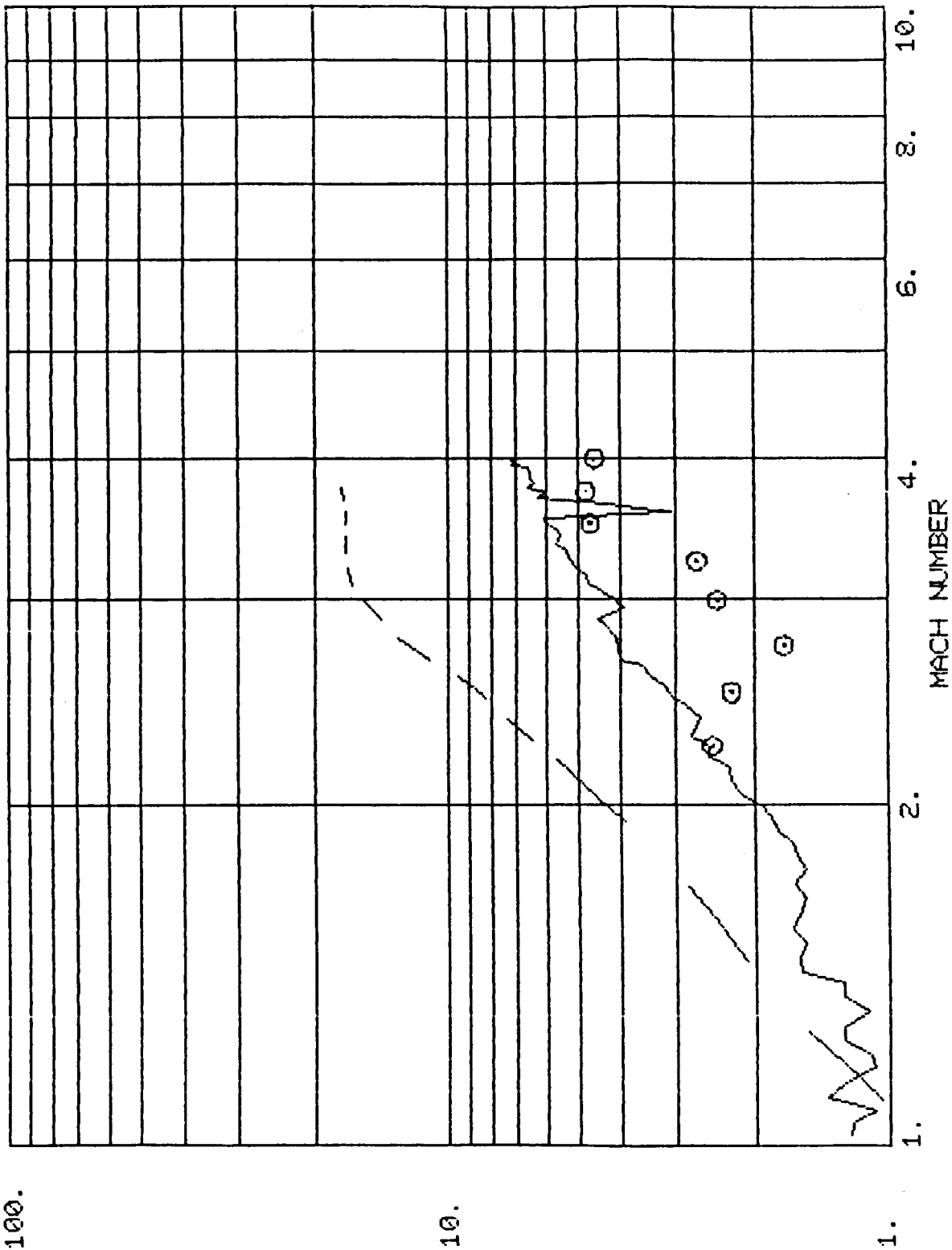
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STS-4 ET FLT (—), RATE1 FRED (---), & IH97-A (O) - GAGE 9038, ISLAND XXX
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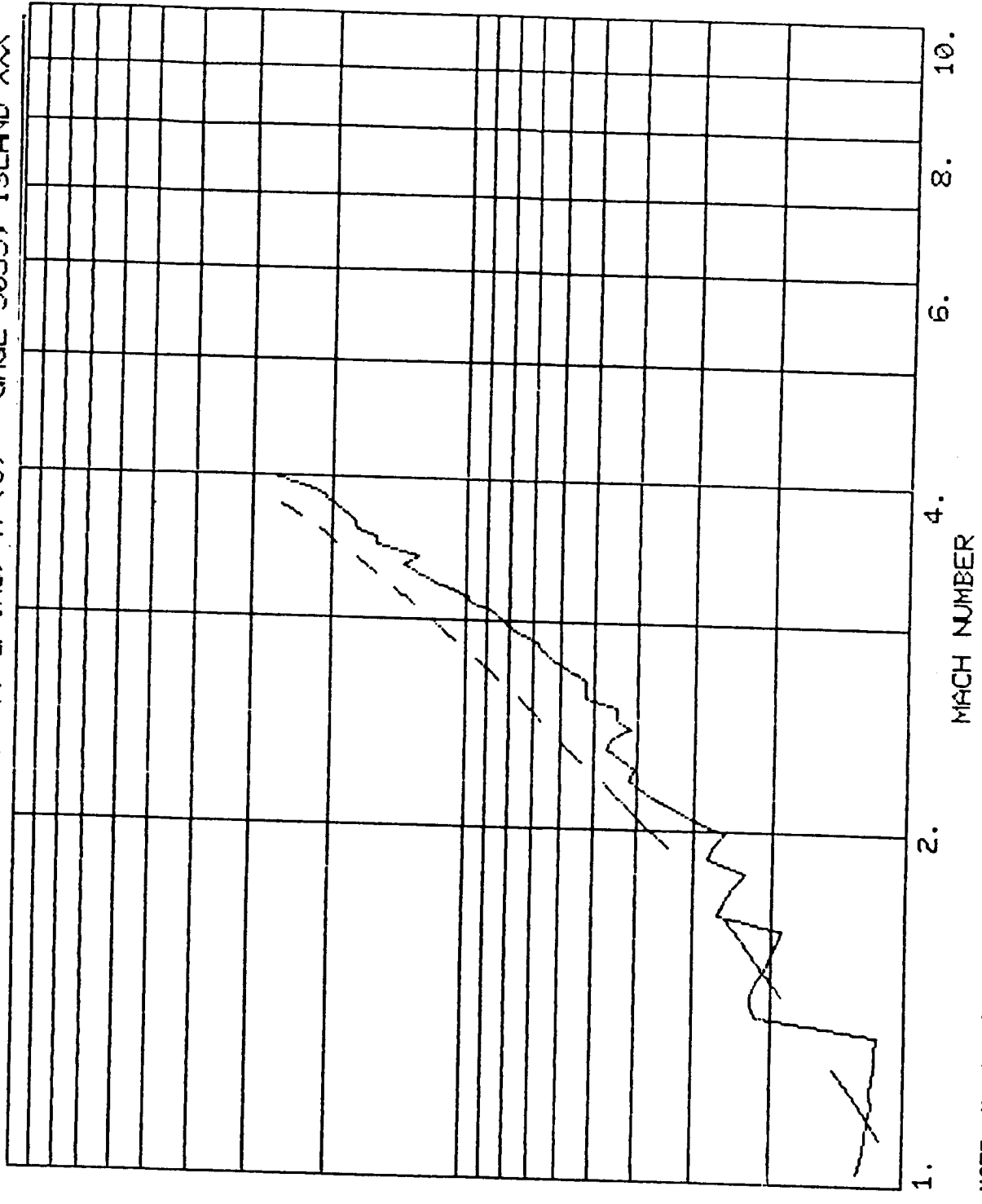
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STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9039, ISLAND XXX
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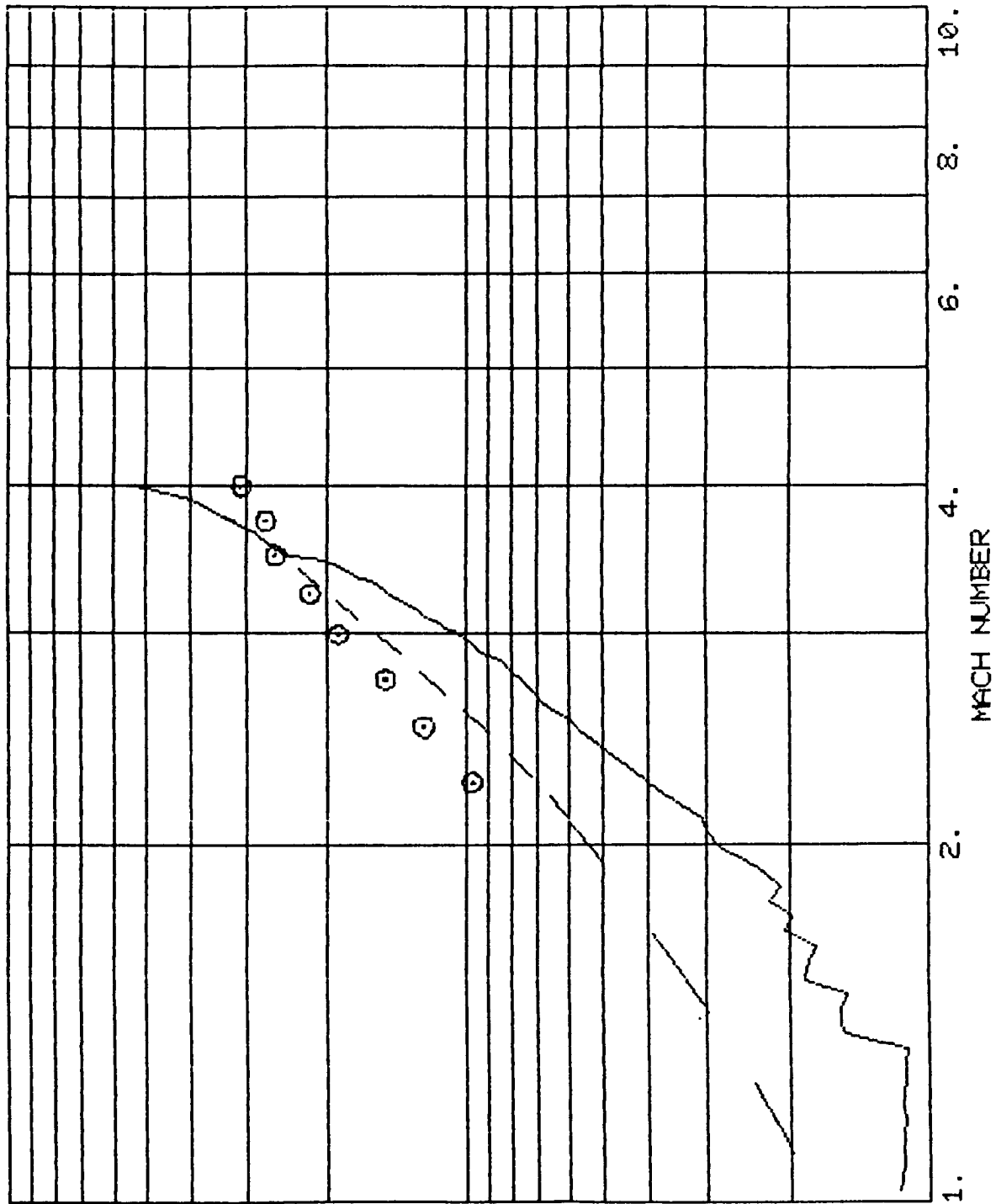


NOTE: No IH-97A Data

STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9041, ISLAND XXX
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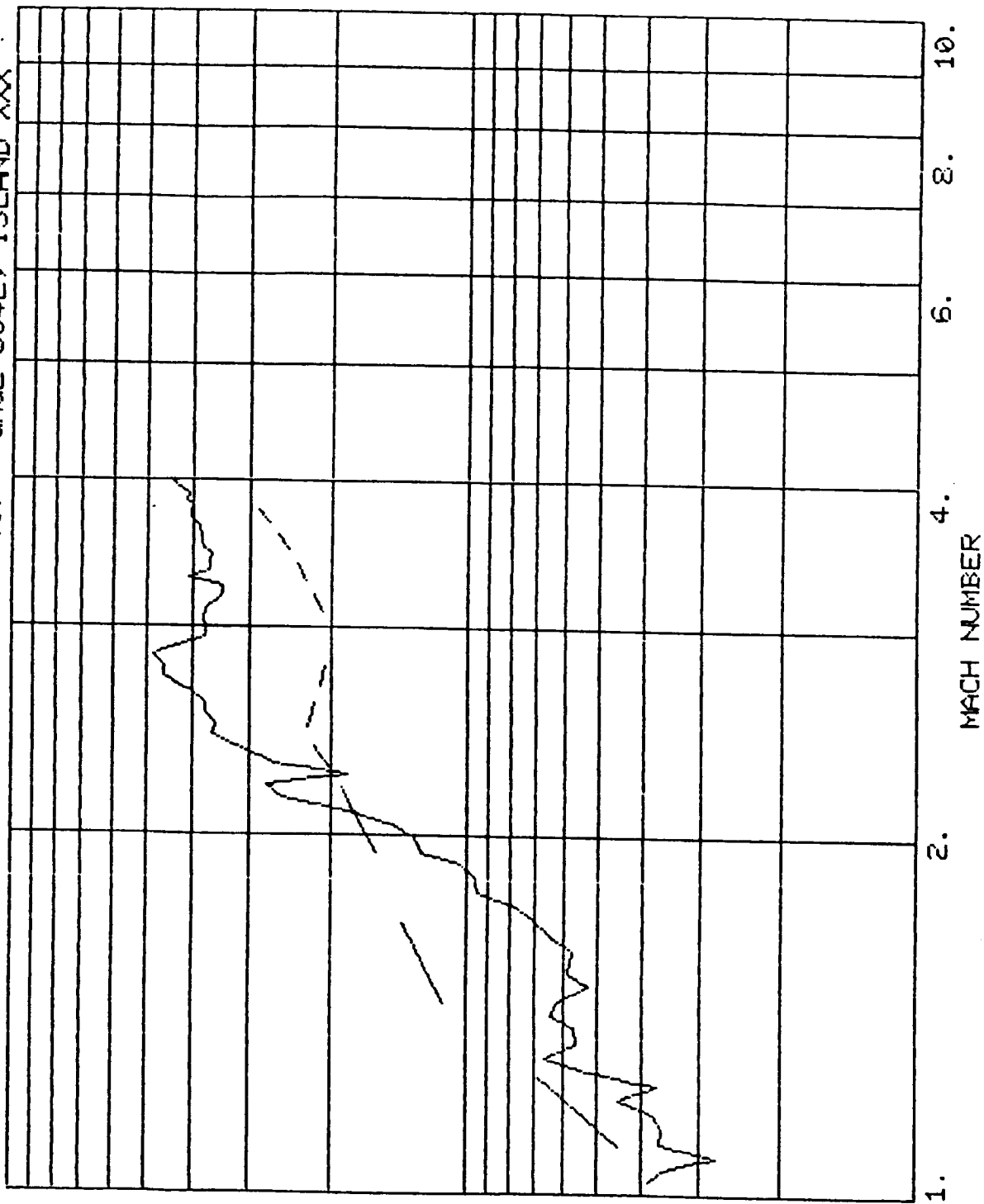


STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (•) - GAGE 9042, ISLAND XXX

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NOTE: No IH-97A Data

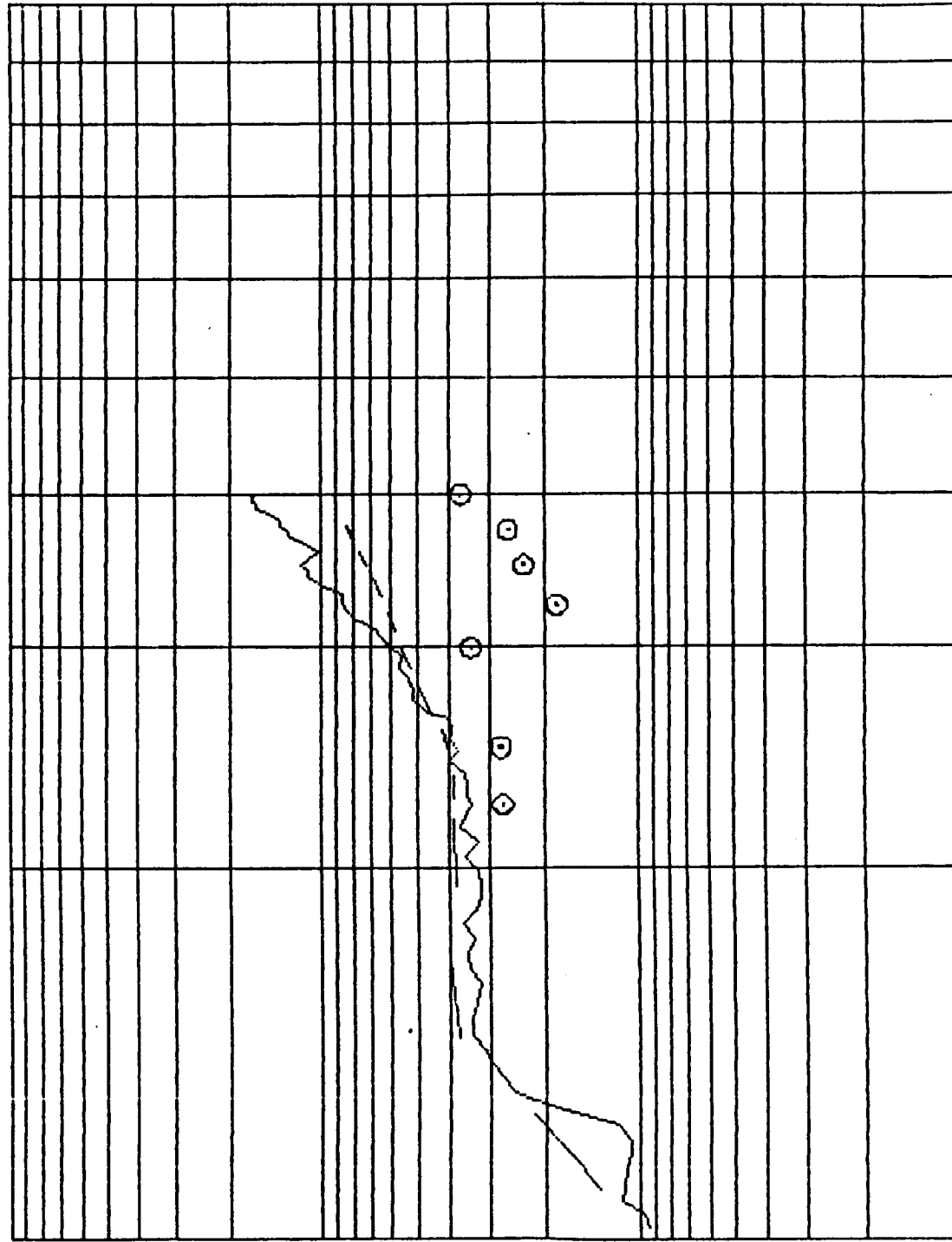
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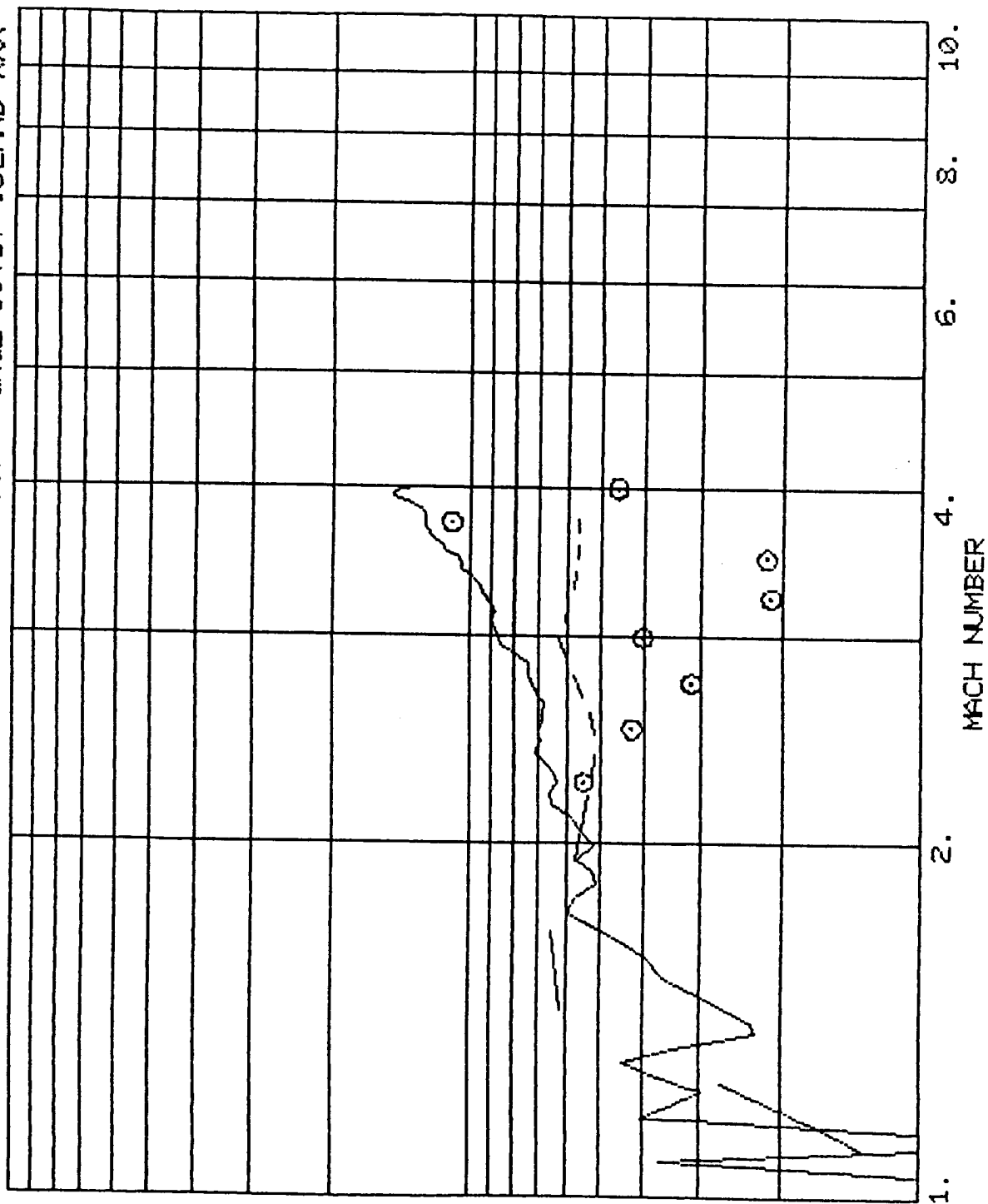


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STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (○) - GAGE 9046, ISLAND XXX
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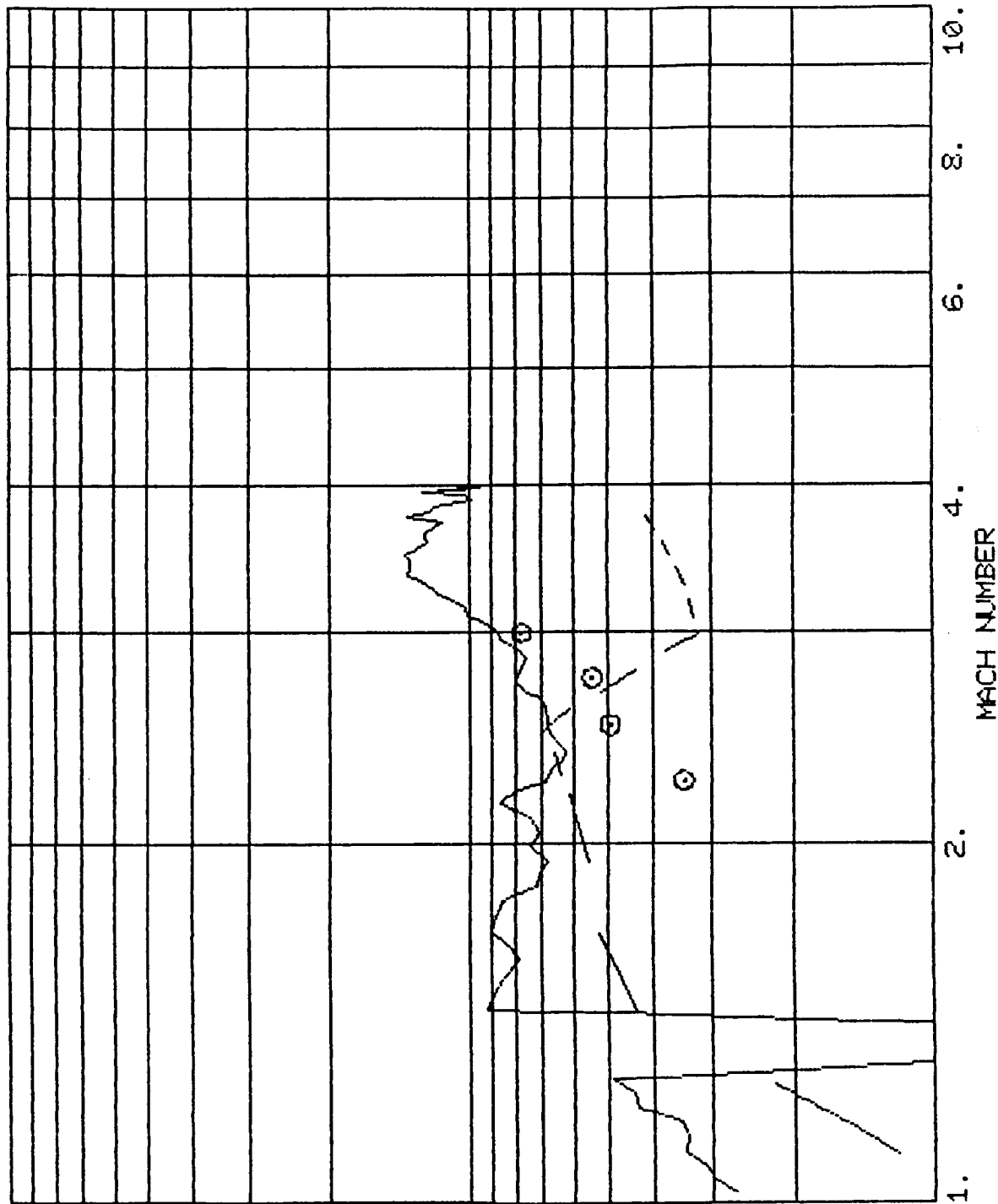
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STS-4 ET FLT (—), RATE1 PRED (---), & IH97-A (O) - GAGE 9047, ISLAND XXX
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H I / H U 10.

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APPENDIX D

FREESTREAM STANTON NUMBER AND REYNOLDS NUMBER CORRELATION FOR FLIGHT AND TUNNEL DATA

REMTECH INC.

TITLE: Wind Tunnel And Flight Data For The ET In The Form Of
Free-stream Stanton Number As A Function Of Reynolds Number
(From RTN 032-18)

DATE: May 1984

AUTHORS: John D. Warmbrod
Amanda L. Boyd

CONTRACT NO: NAS8-32969

PREPARED FOR: George C. Marshall Space Flight Center

Introduction

In the year 1874, Osborne Reynolds published a paper which suggested that momentum and heat in a fluid are transferred in the same way. He showed for incompressible flow that the non-dimensional form of the momentum and heat transfer equations are directly proportional where the non-dimensional quantities are defined below:

Momentum - Skin Friction Coef. $C_f = \frac{\tau_w}{1/2 \frac{\rho}{g} V^2} \approx Re$

Heat Transfer - Stanton Number $St = \frac{\dot{q}}{\rho V (H - H_w)} = \frac{h}{\rho V} \approx Re$

where

τ_w = Wall Shear Stress, lb_f/ft^2

ρ = Density (Free-stream or Edge), lb_m/ft^3

V = Velocity (Free-stream or Edge), ft/sec

Re = Reynolds Number Based On Running Length

\dot{q} = Heat Flux Into Wall, $Btu/ft^2 sec$

h = Heat Transfer Coefficient, $lbm/ft^2 sec$

H = Enthalpy (Recovery or Total),

H_w = Wall Enthalpy, Btu/lb_m

Reynold's original expression for the analogy between heat transfer and skin friction for incompressible flow was

$$St = \frac{C_f}{2S}$$

where S is called the Reynolds Analogy Factor. Reynolds assigned a value of $S = 1$ whereas, other definitions for S have been subsequently developed (Colburn, Karman, Kozlov, Spaulding and Chi).

Various authors have shown that theoretical and experimental results for the Stanton number exhibit the following trends with Reynolds Number for laminar and turbulent boundary layers.

Laminar	$St (Re)^{1/2} \approx \text{Constant}$
Turbulent	$St (Re)^{1/5} \approx \text{Constant}$

Another way of collapsing heat transfer data has been in the form of the Nusselt Number which is defined by

$$N_u = \frac{C_p h S}{K} = Re \cdot Pr \cdot St$$

where

C_p = Specific Heat ($\approx .24$ for air), Btu/lb_m^oR

h = Heat Transfer Coefficient, lb_m/ft²sec

S = Running Length, ft

K = Thermal Conductivity, Btu/ftsec^oR

Pr = Prandtl Number ($\approx .72$ for Air)

Re = Reynolds Number Based On Running Length

The above non-dimensional parameters can be defined by using either free-stream or boundary layer edge properties.

Flight And Wind Tunnel Data Plots

The External Tank was instrumented to measure surface heat fluxes and pressures for Shuttle Missions STS 1-5 and 7. The flight heat transfer data measured on the nose cone, ogive, barrel ($X_T \leq 1500$) and selected protuberances were reduced to the form of Stanton Number and unit Reynolds Number based on free-stream properties. Table 1 shows the calorimeter locations and gage identifications along with the flights for which each calorimeter was installed. The heat transfer data measured by the calorimeters identified in Table 1 are presented in Figures 1-22 as free-stream Stanton Number as a function of free-stream Reynolds Number. The presentation of this data for Stanton Number and Reynolds Number as a function of boundary layer edge properties might further collapse the data since the angle of attack effects will be removed. One interesting observation made from the data presented in Figures 1-22 is that the data does not closely follow the turbulent trend ($St (Re)^{1/5} \approx \text{constant}$).

The primary objective of this memo is to document the reduction of the flight data in Stanton/Reynolds Number form. It is expected that this data might lead to alternative methodologies for predicting design environments on the External Tank.

TABLE 1: ET Flight Instrumentation For Which Heat Transfer Data Was Reduced To Stanton Number As A Function Of Reynolds Number

Acreage Or Protuberance	Island	Gage	X_T (IN)	θ_T (DEG)	STS Flights	Location Description
Acreage ↓	---	R9001	350	180.0	1,2,3,4,5,7	40° Cone
	1	9005	467.4	174.0	2,3,4,5,7	Ogive - LO ₂
	2	9004	467.4	354.0	↓	↓
	5	9008	672.5	180.0	↓	↓
	6	9007	672.5	270.0	↓	↓
	8	9010	825.5	270.0	↓	↓
	14	9016	937.4	251.4	1,2,3,4,5,7	Barrel - LO ₂
	15	9015	956.2	270	↓	Barrel - 1/T
	16	9014	937.4	288.6	↓	↓
	17(1)	9019	1084.4	2.5	↓	↓
	17(2)	9018	1098.5	2.5	↓	↓
	17(3)	9013	1110.4	2.5	↓	↓
	18	9011	976.0	25.0	↓	↓
	23	9022	1082.0	180.0	↓	↓
	26	9023	1130.3	0.0	4,5,7	Barrel - LH ₂
	27	9020	1147.4	358.0	4,5,7	↓
	28	9026	1489.0	172.5	3,4,5,7	↓
Protuberance ↓	---	9039	1130	---	1,2,3,4,5,7	BI-Pod
	---	9041	959.3	---	↓	Bolt Catcher
	---	9038	---	---	↓	Feedline Fairing
	---	9042	---	---	↓	Thrust Strut
	---	9040	1322.0	---	5	Cable Tray Top

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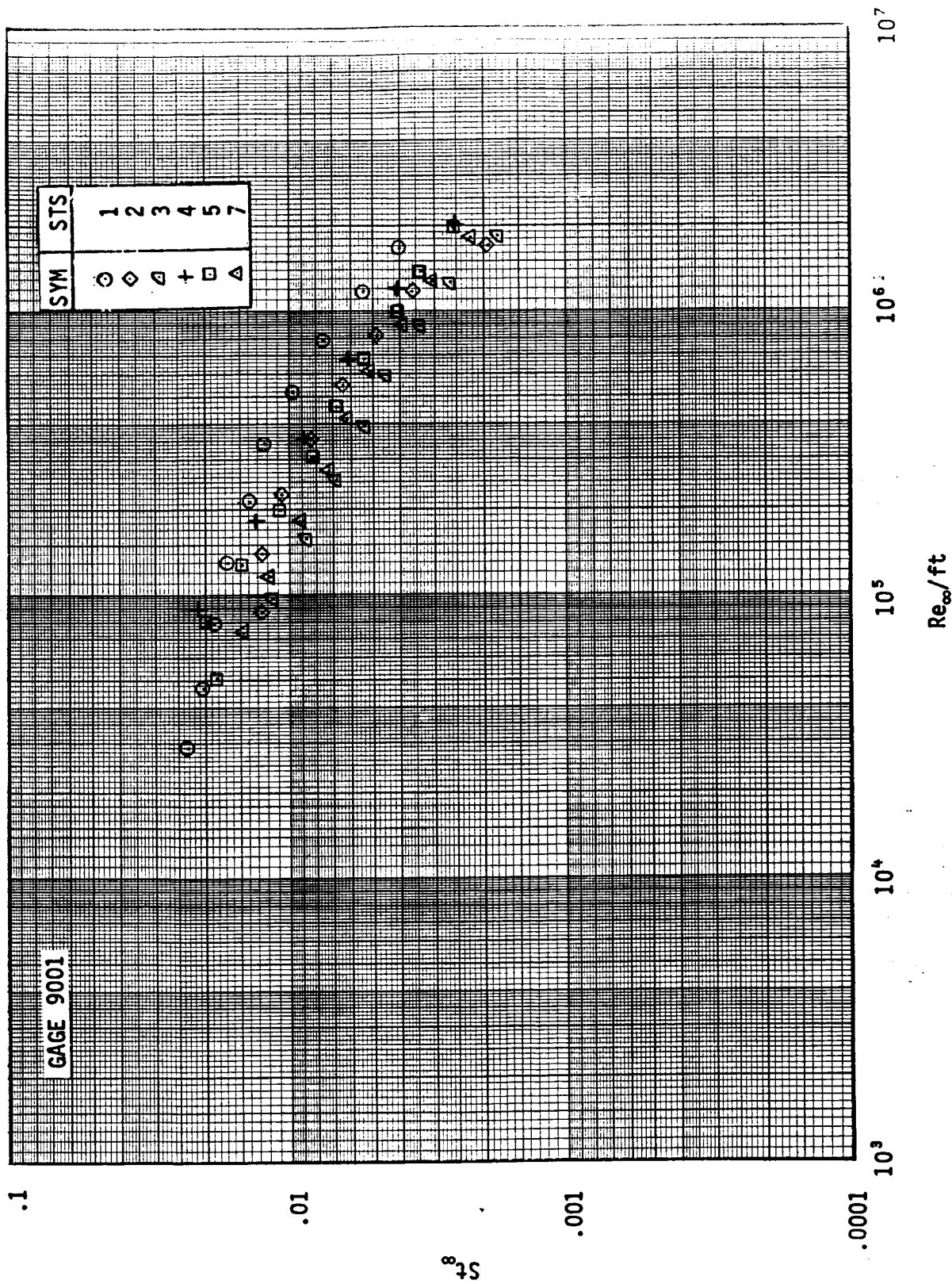


Fig.1 Stanton Number As A Function Of Reynolds Number For Gage 9001

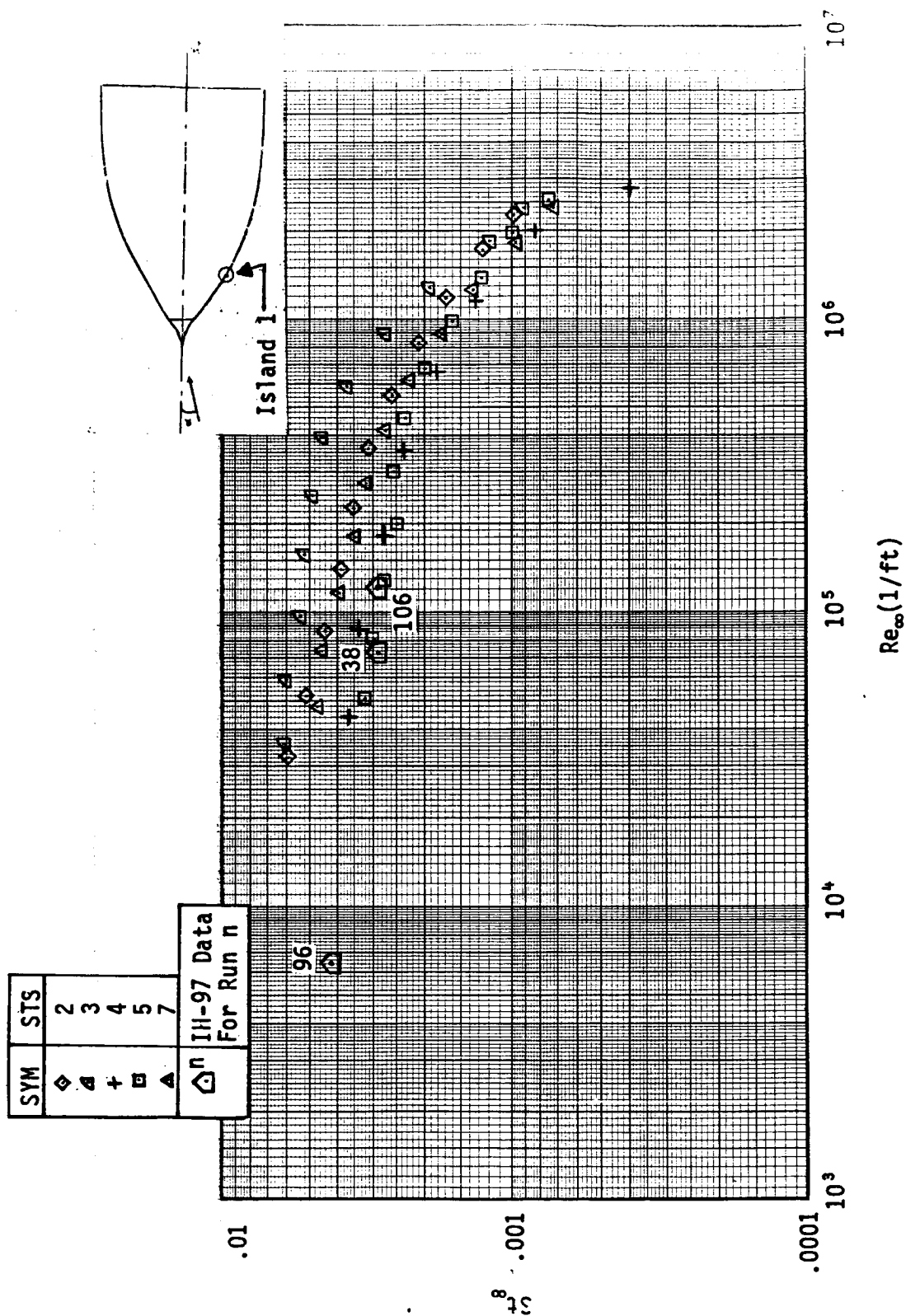
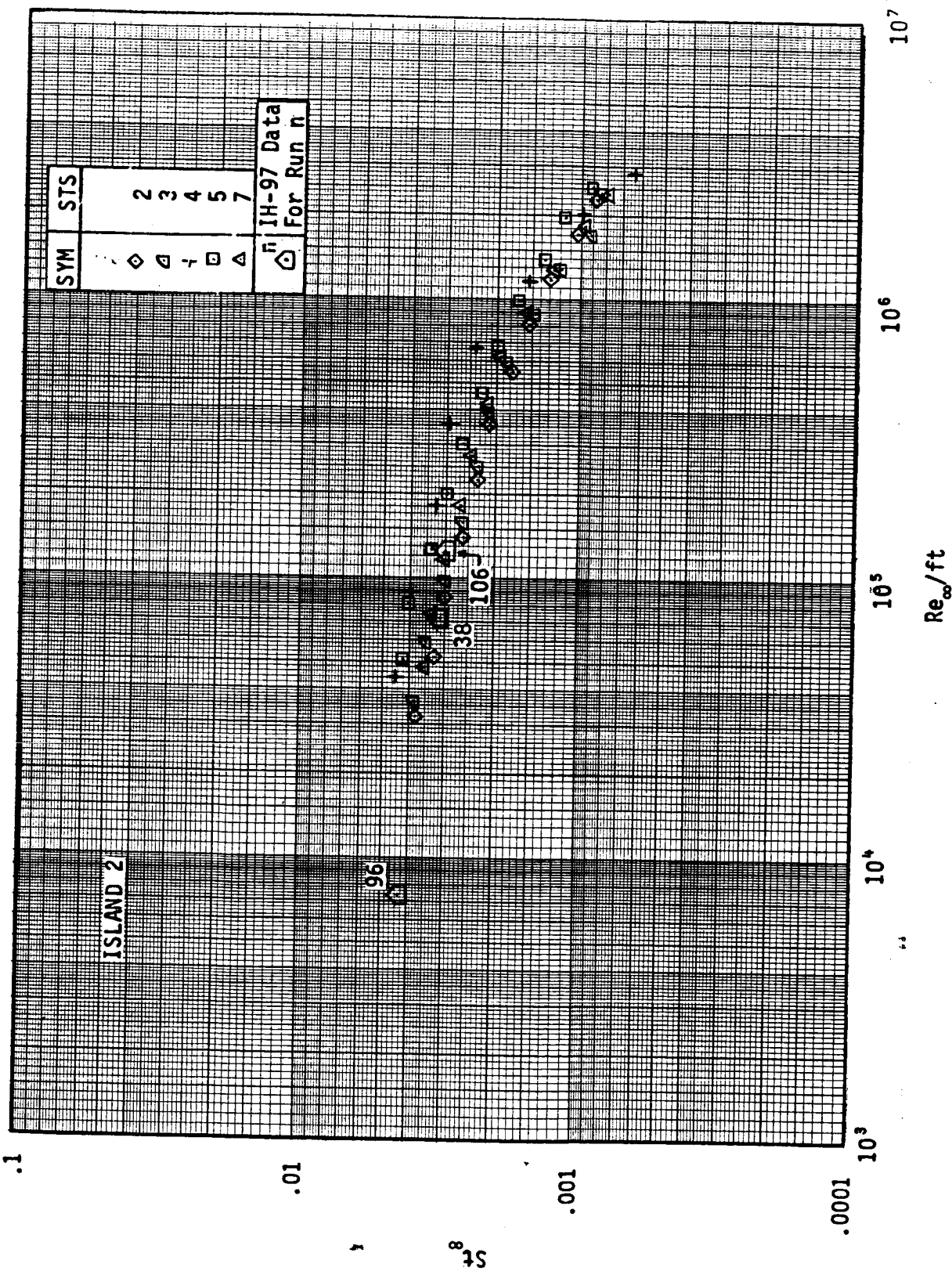


Fig. 2 Stanton Number As A Function Of Reynolds Number For Island 1



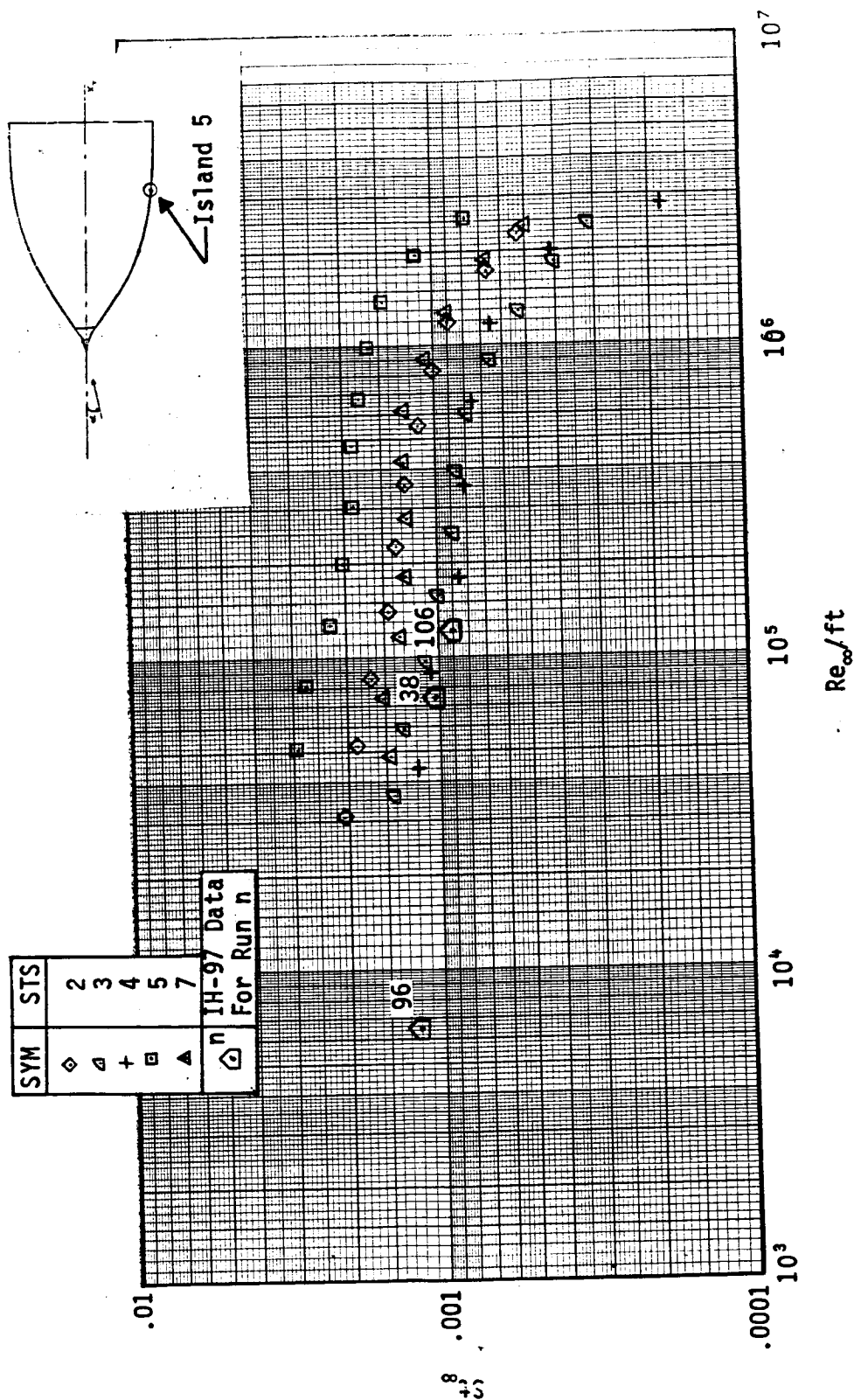


Fig.4 Stanton Number As A Function Of Reynolds Number For Island 5

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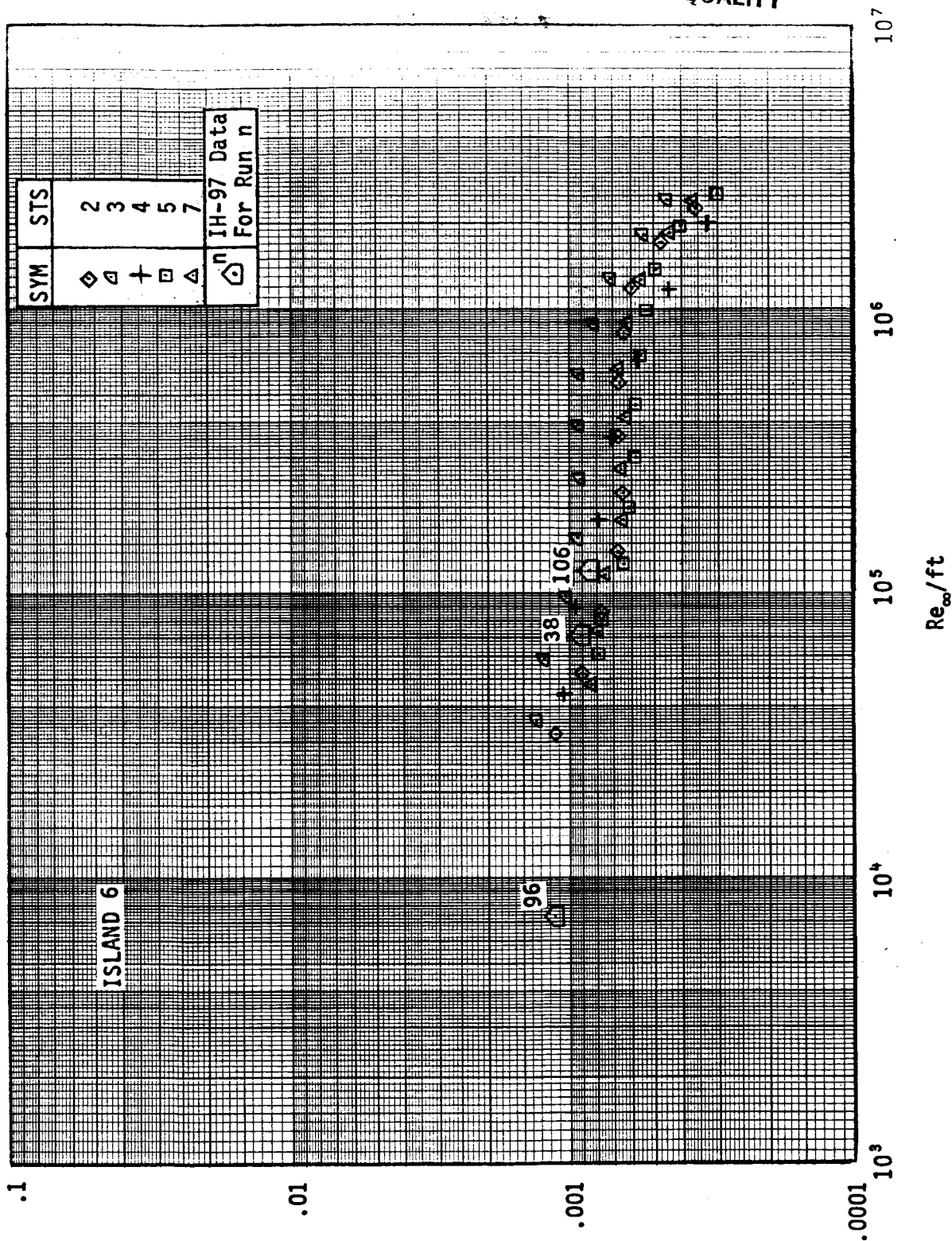


Fig.5 Stanton Number As A Function Of Reynolds Number For Island 6

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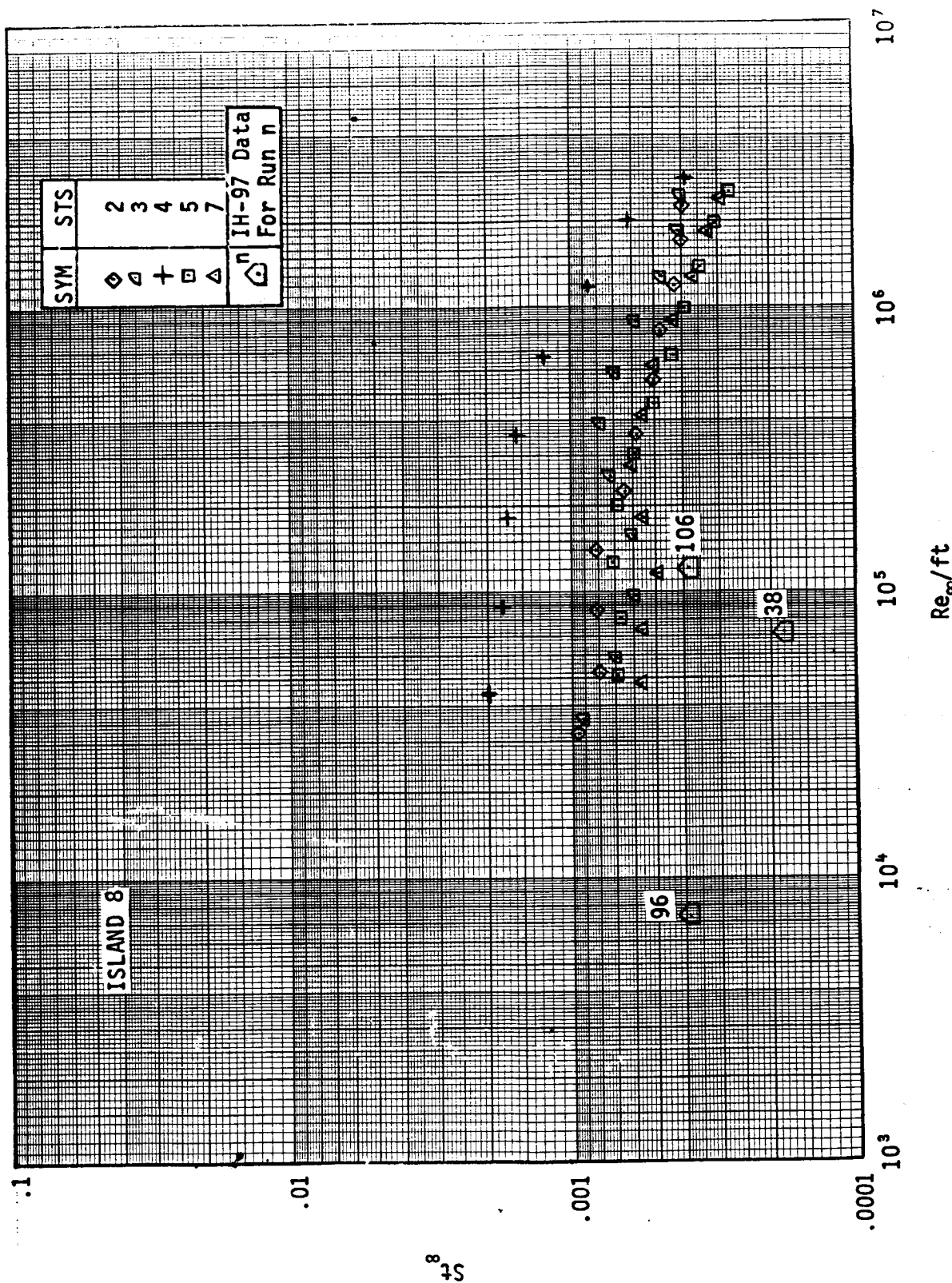


Fig. 6 Stanton Number As A Function Of Reynolds Number For Island 8

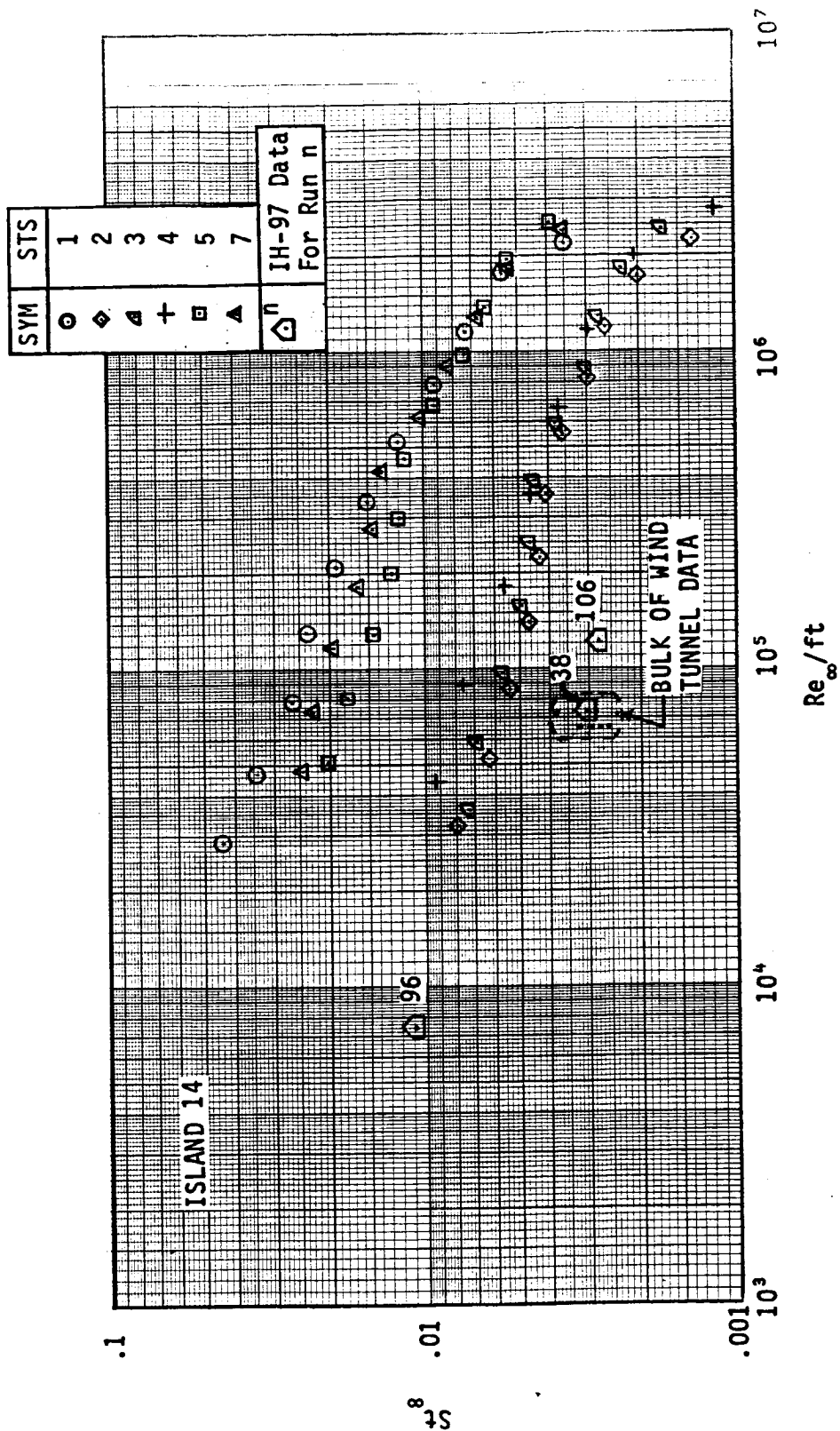


Fig. 7 Stanton Number As A Function Of Reynolds Number For Island 14

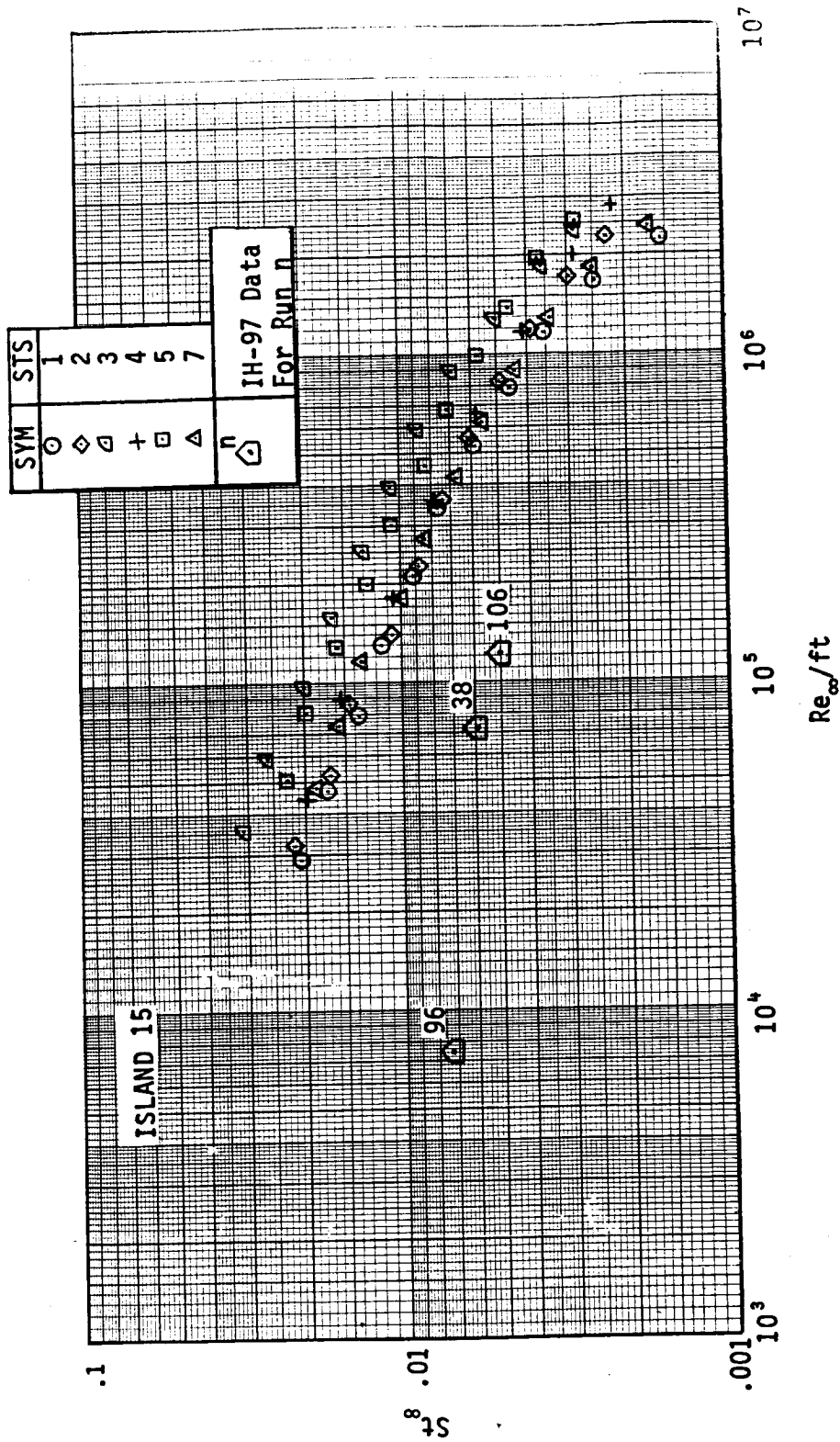


Fig. 8 Stanton Number As A Function Of Reynolds Number For Island 15

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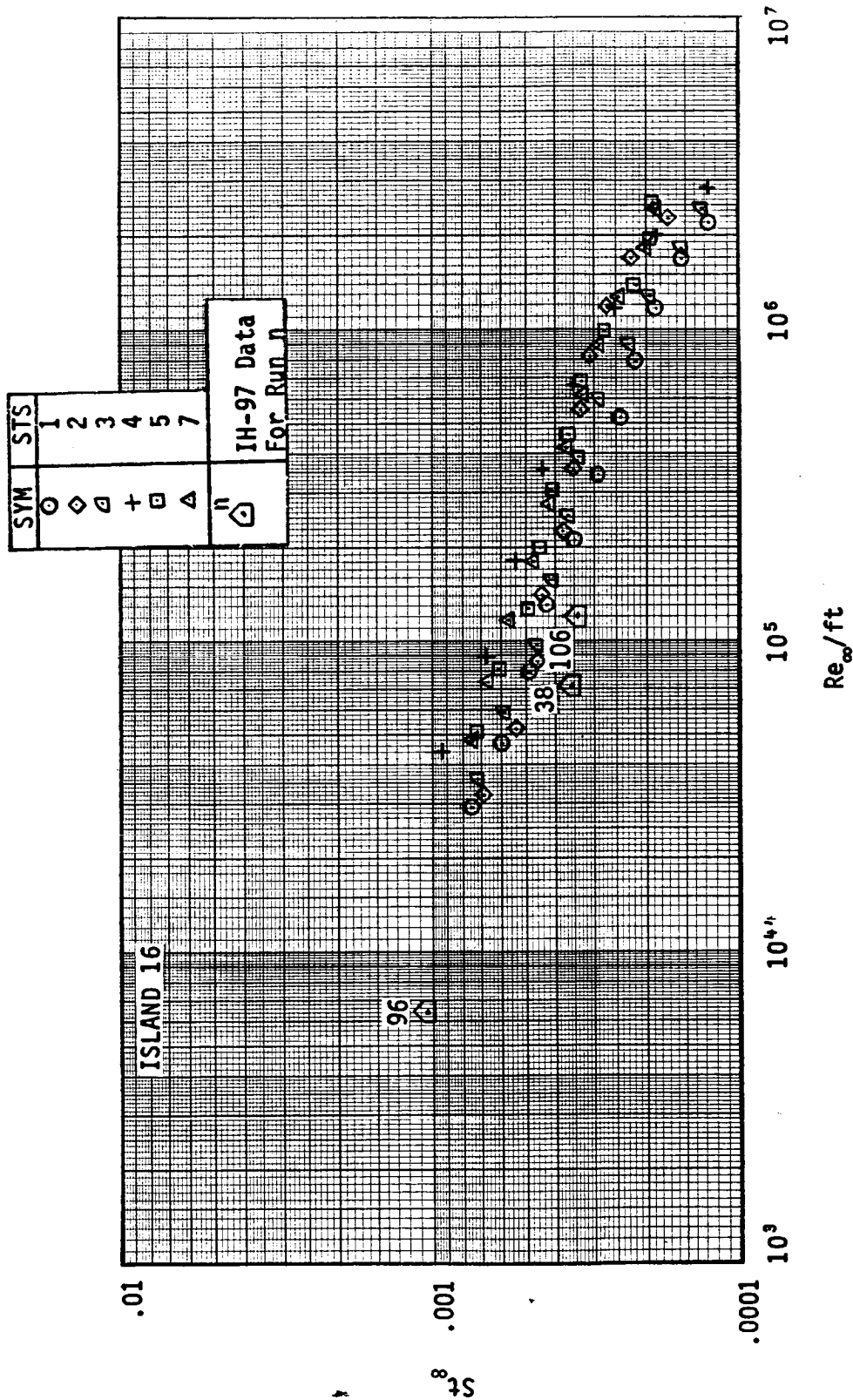


Fig. 9 Stanton Number As A Function Of Reynolds Number For Island 16

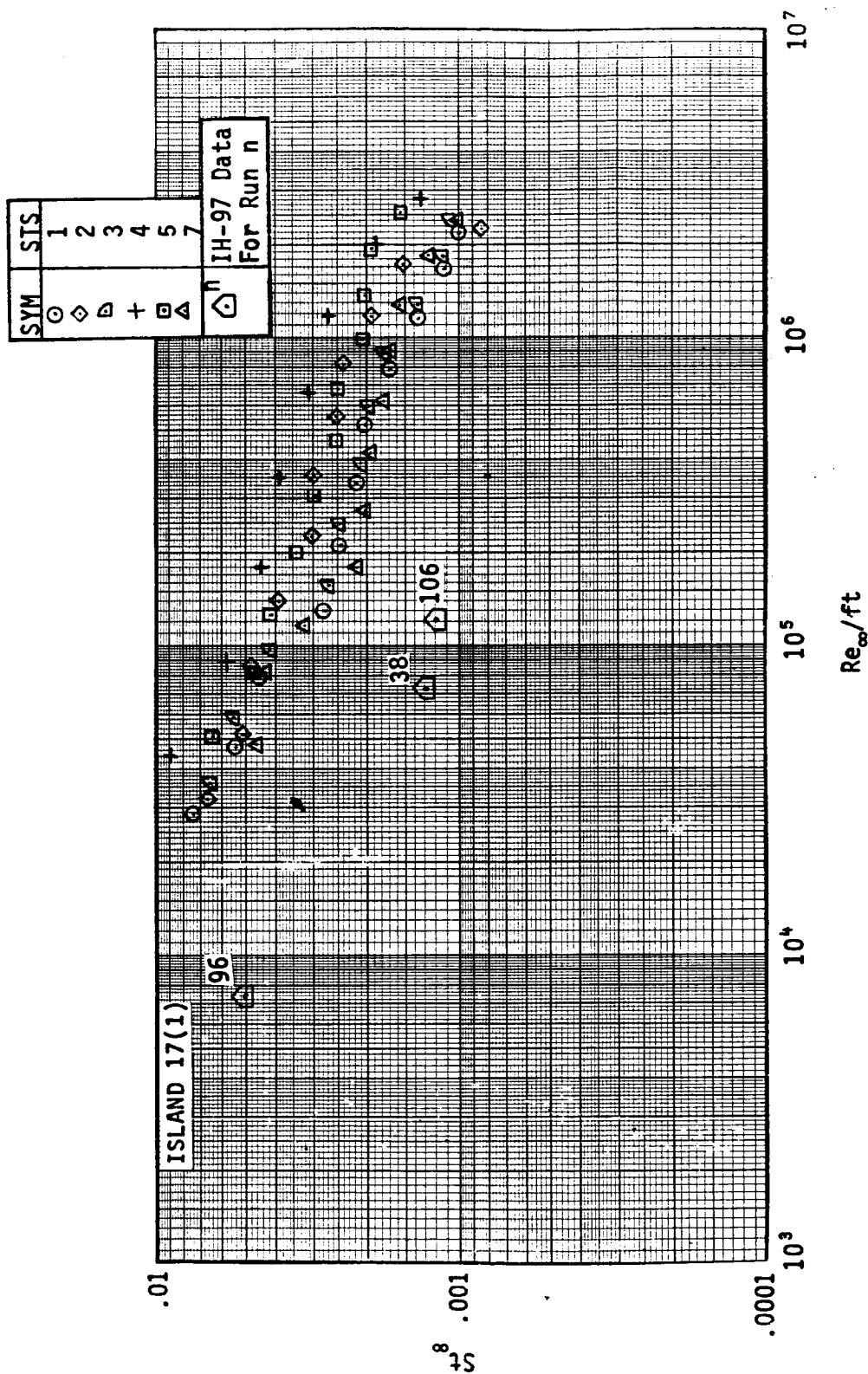


Fig. 10 Stanton Number As A Function Of Reynolds Number For Island 17(1)

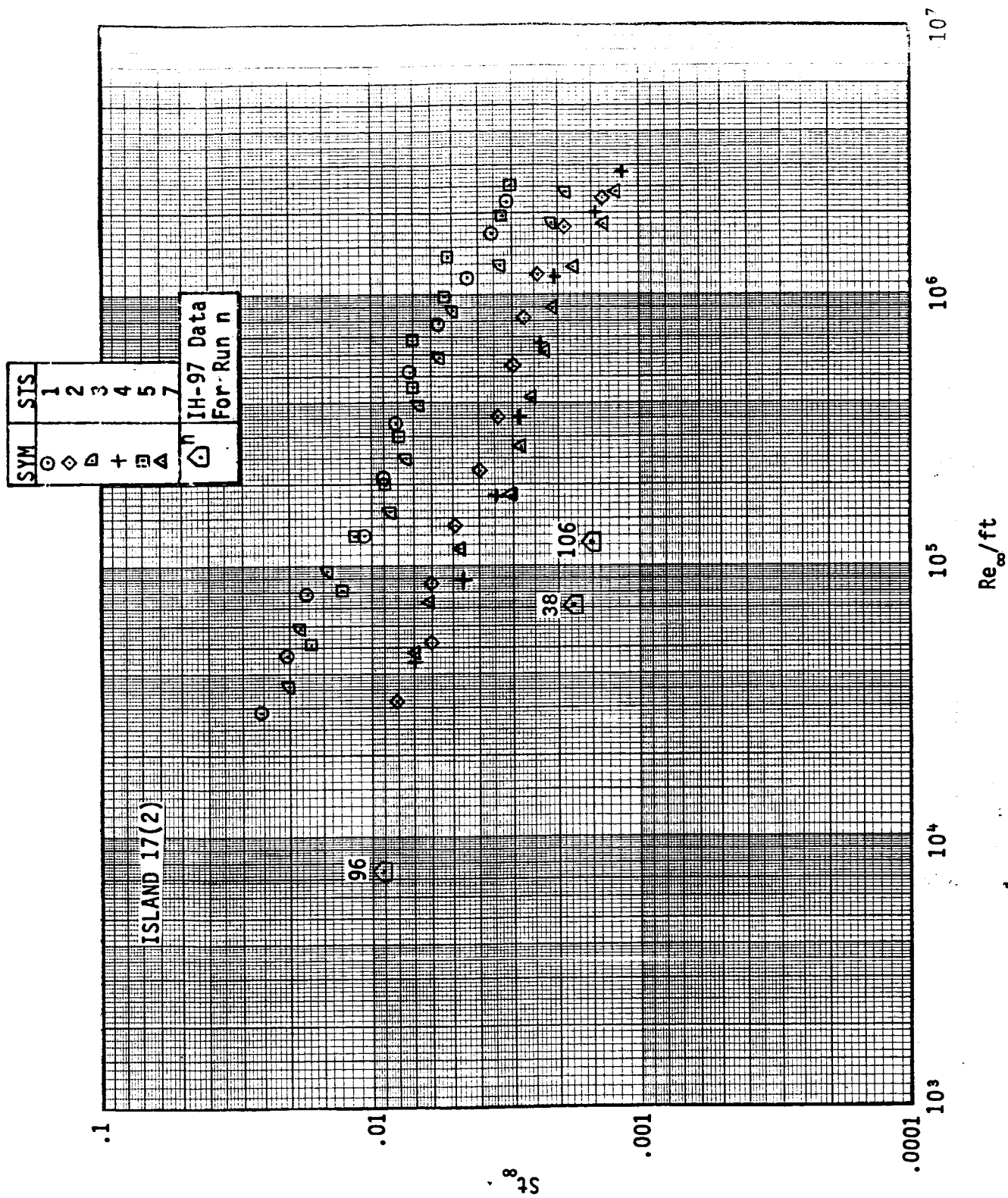


Fig. 11 Stanton Number As A Function Of Reynolds Number For Island 17(2)

Fig. 12 Stanton Number As A Function Of Reynolds Number For Island 17(3)

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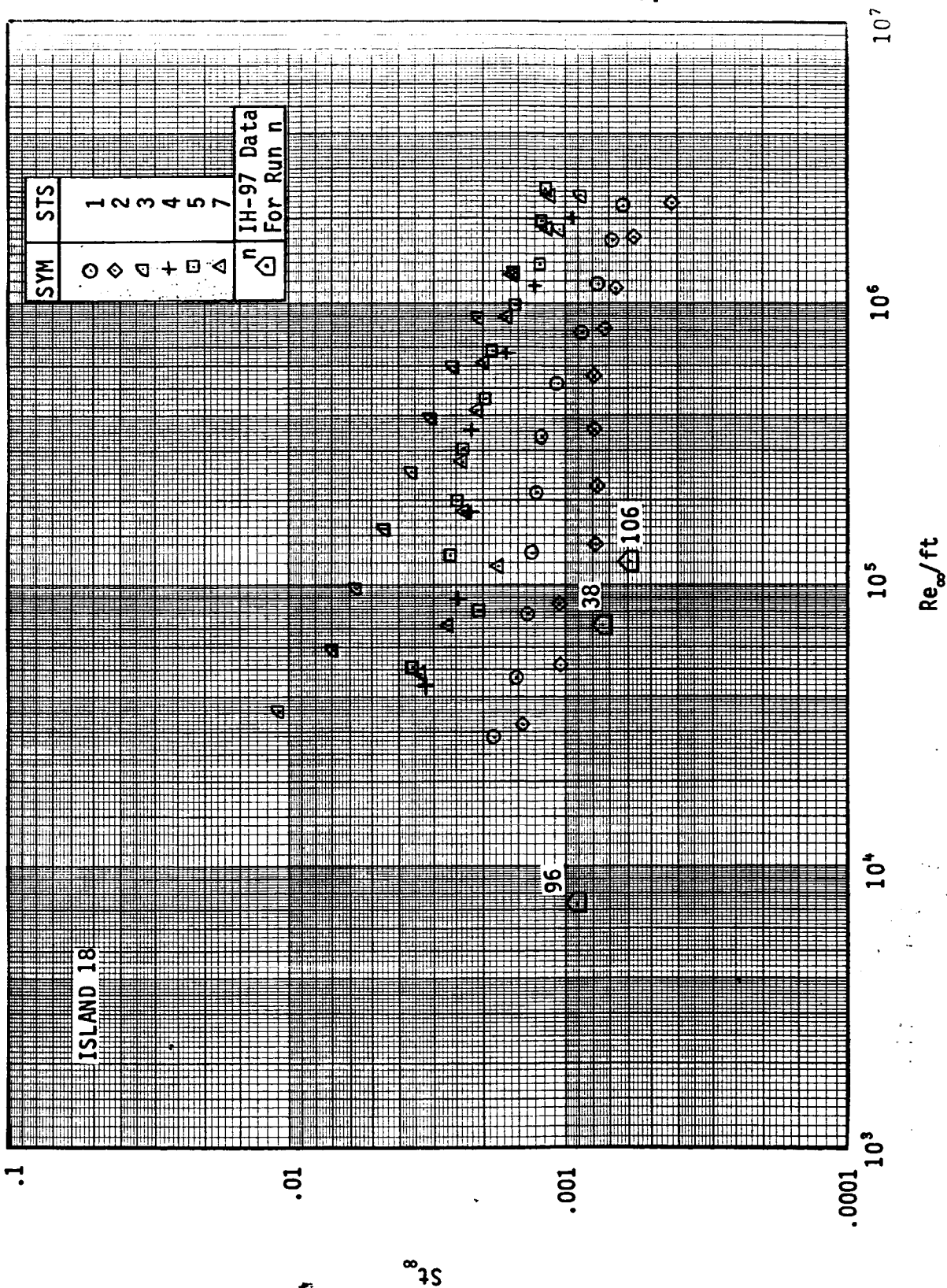


Fig. 13 Stanton Number As A Function Of Reynolds Number For Island 18

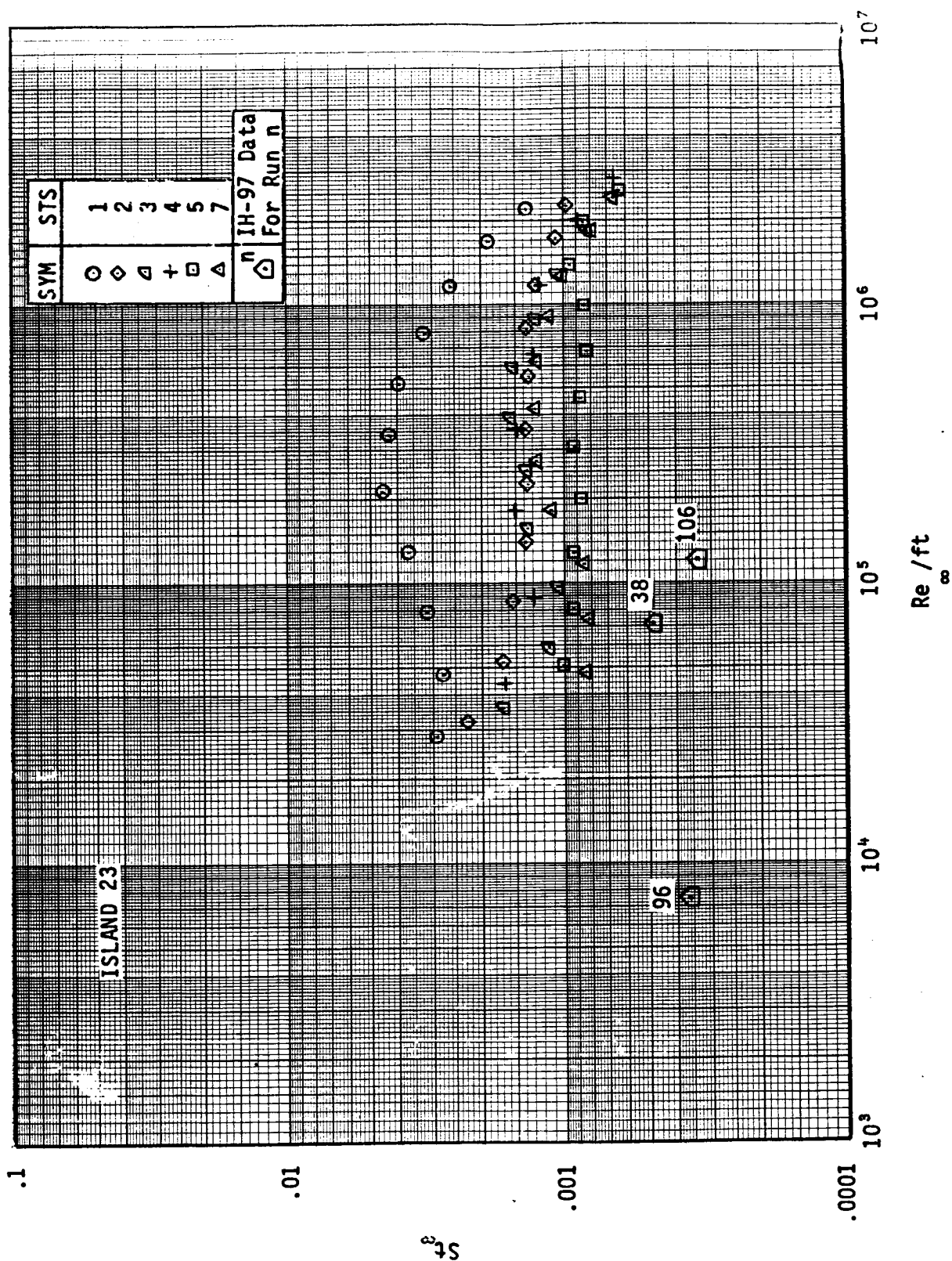
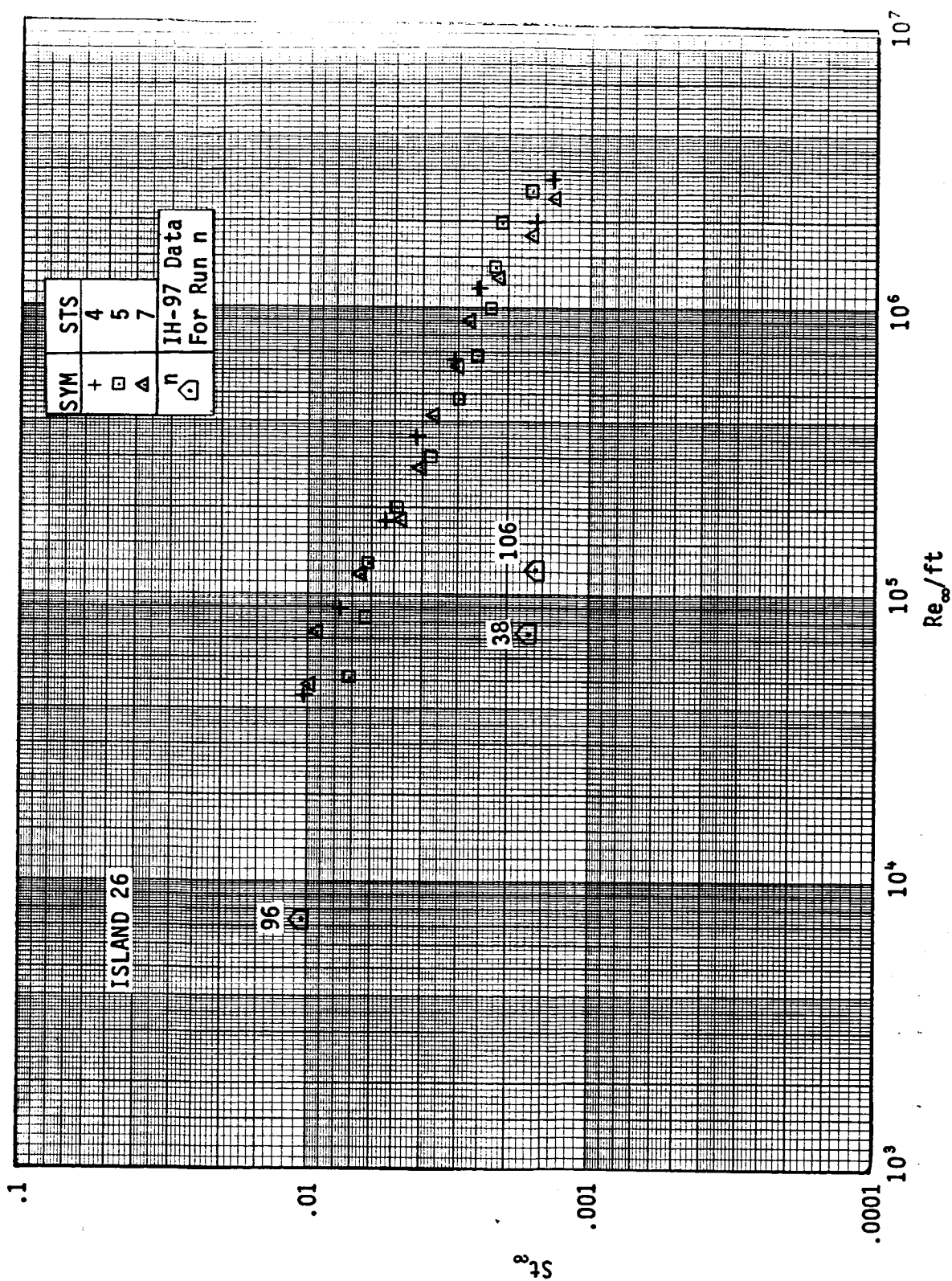


Fig. 14 Stanton Number As A Function Of Reynolds Number For Island 23



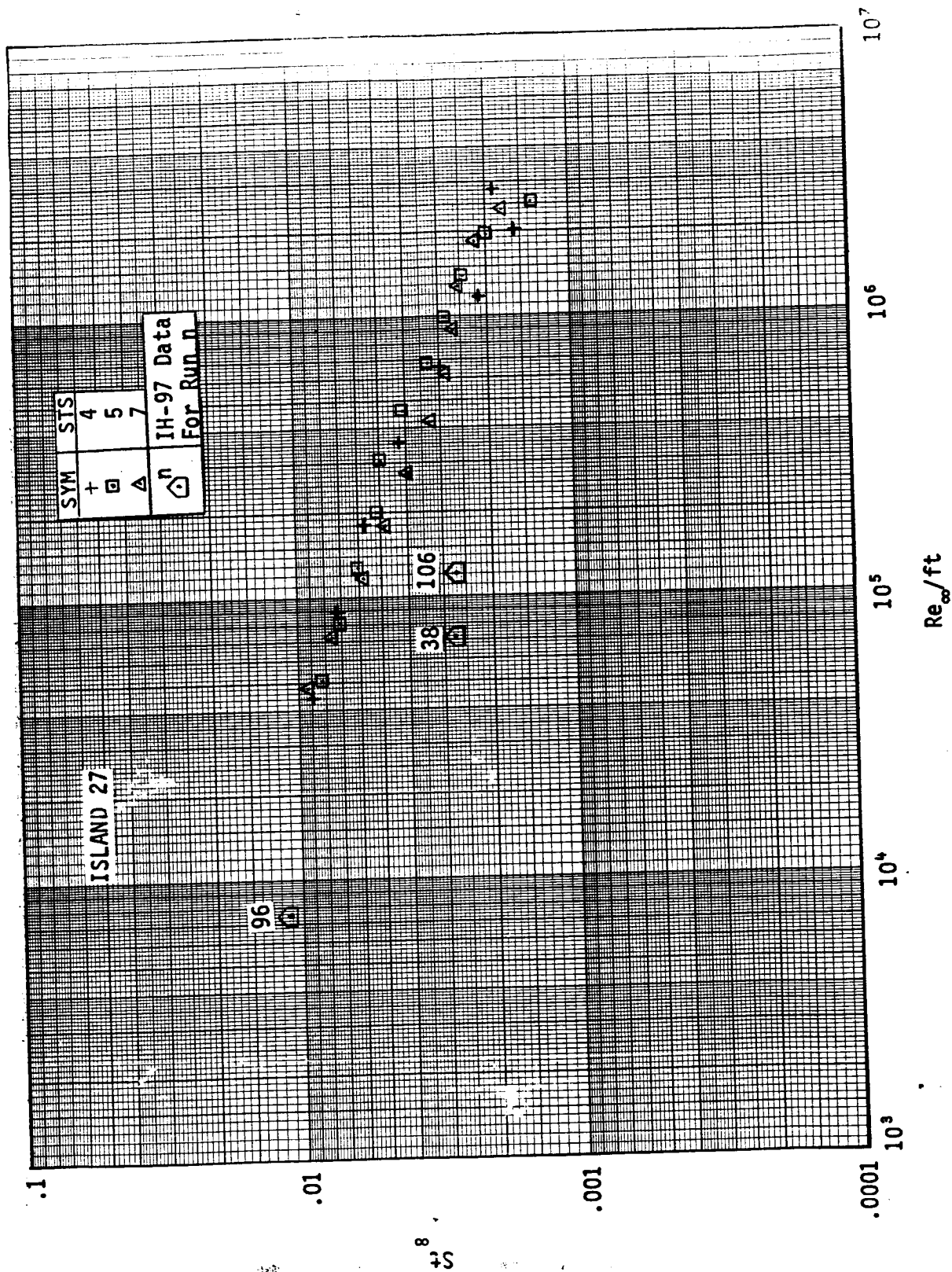


Fig. 16 Stanton Number As A Function Of Reynolds Number For Island 27

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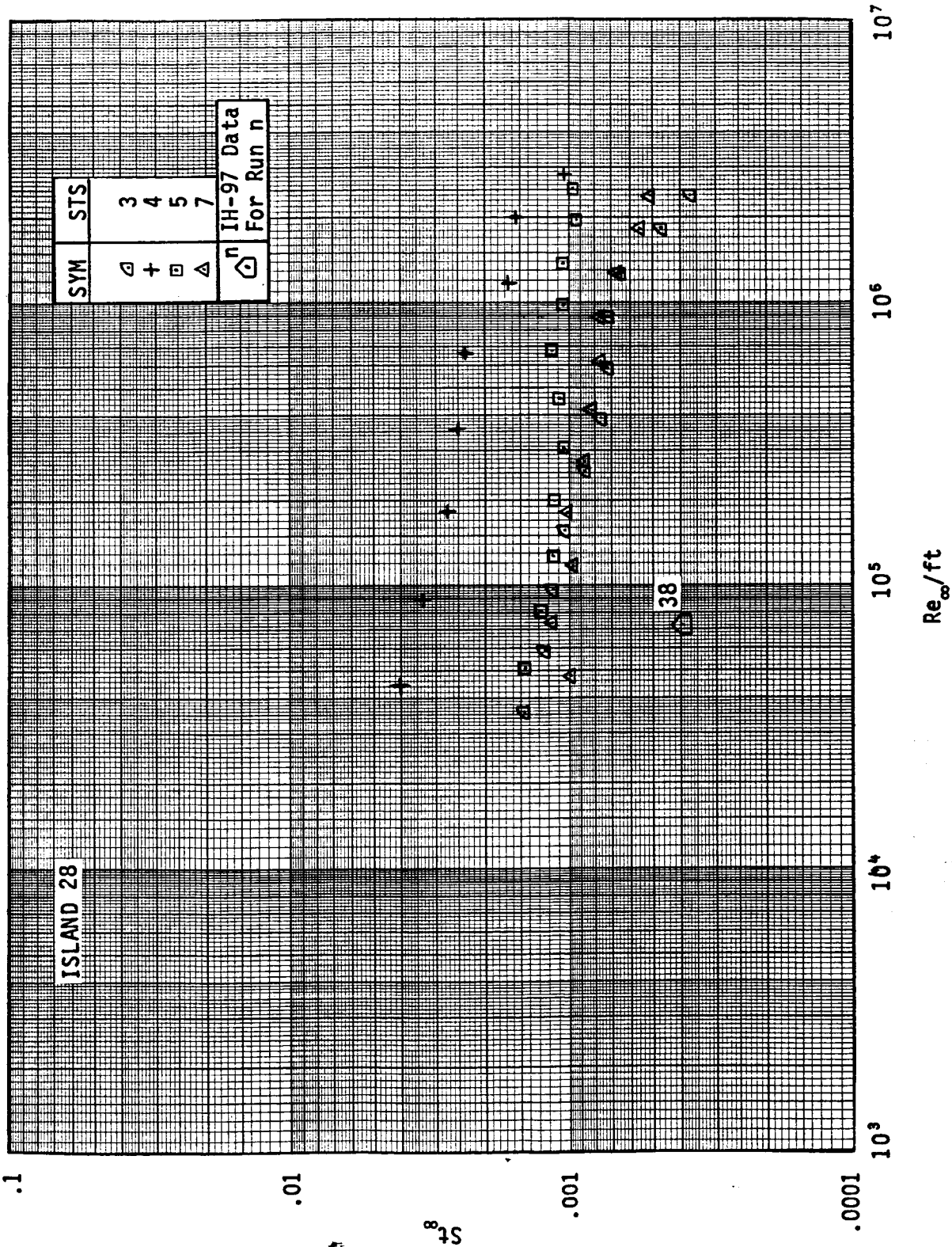


Fig. 17 Stanton Number As A Function Of Reynolds Number For Island 28

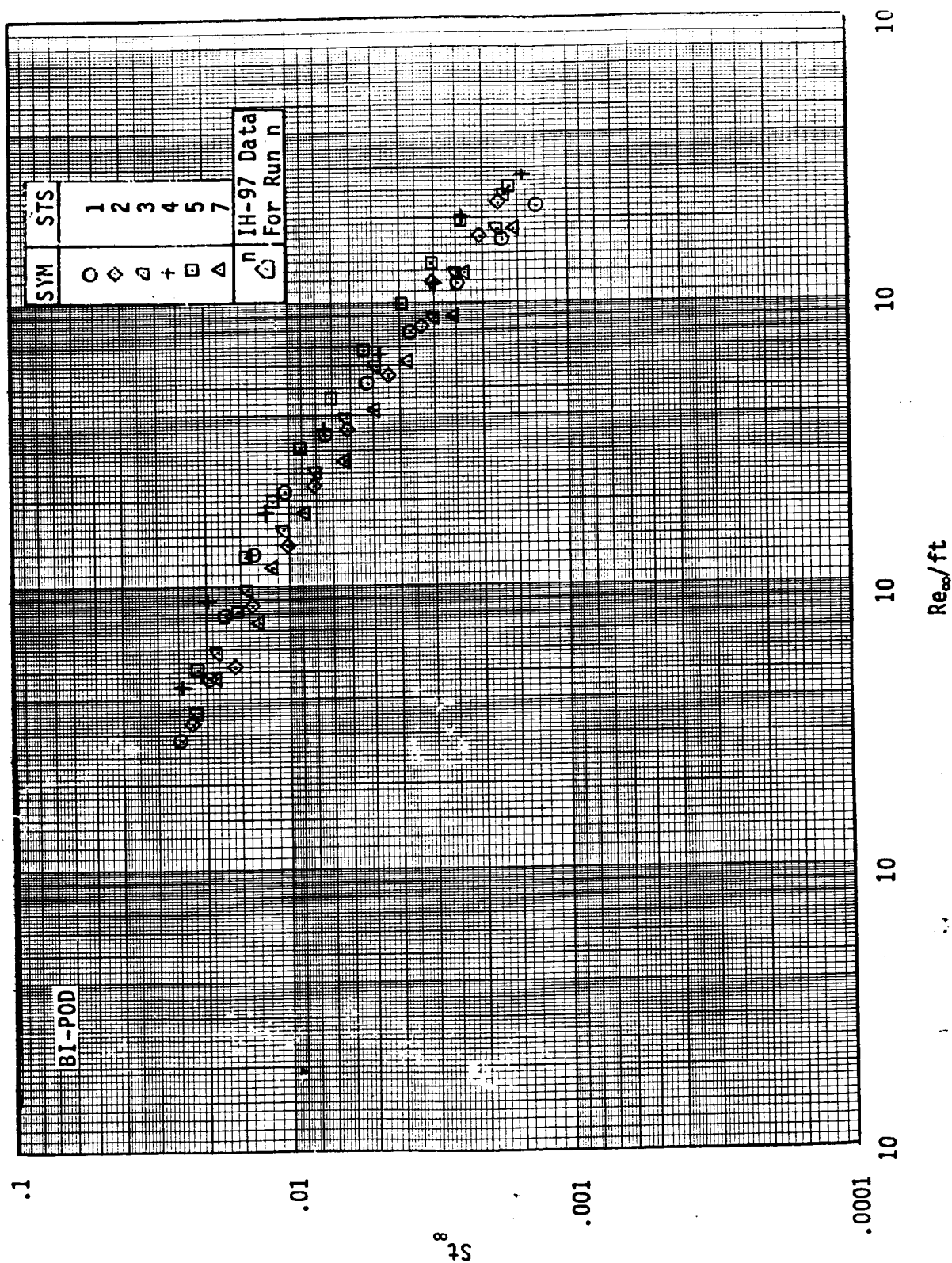


Fig. 18 Stanton Number As A Function Of Reynolds Number For Bi-Pod

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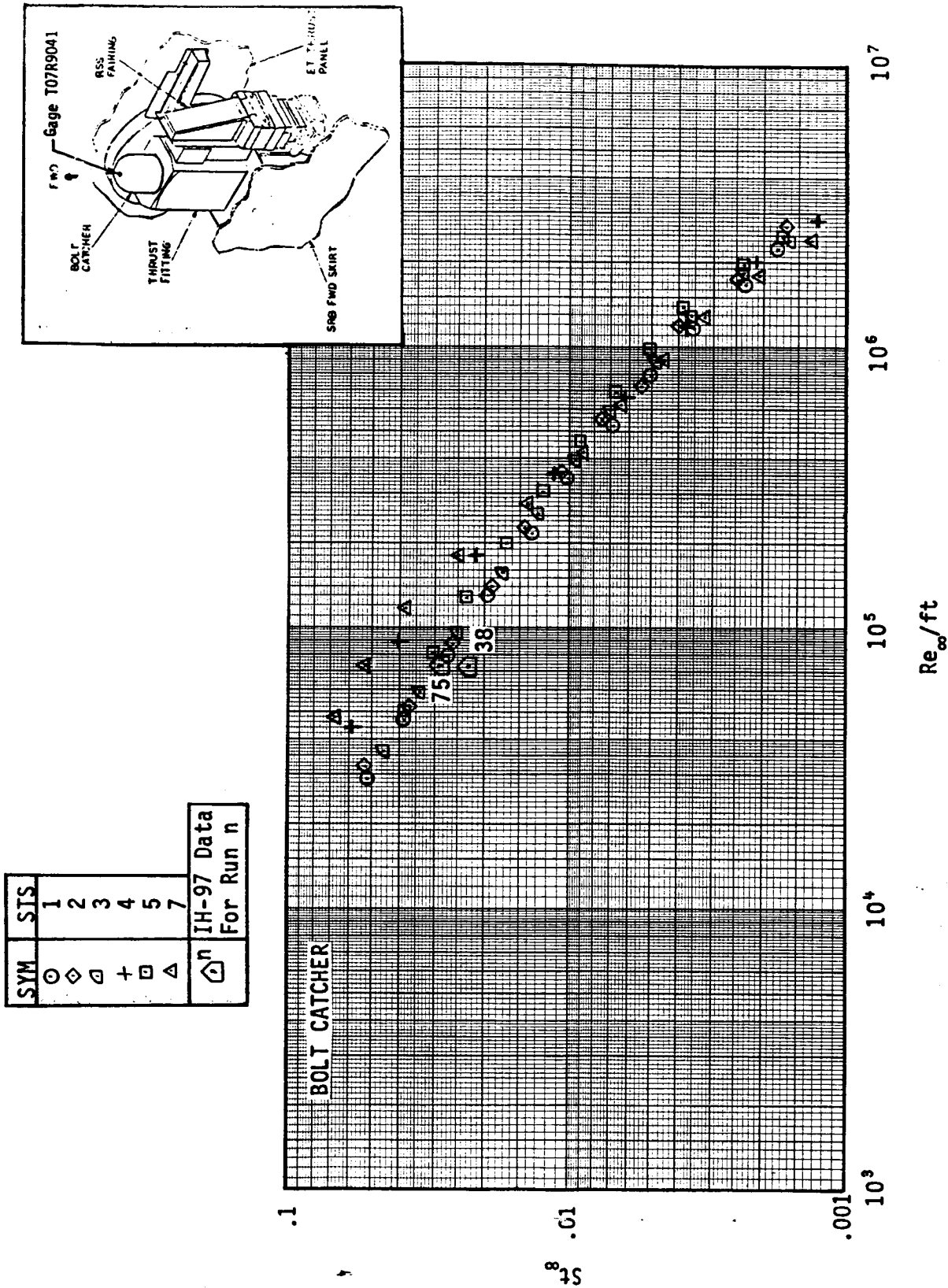


Fig. 19 Stanton Number As A Function Of Reynolds Number For Boltcatcher

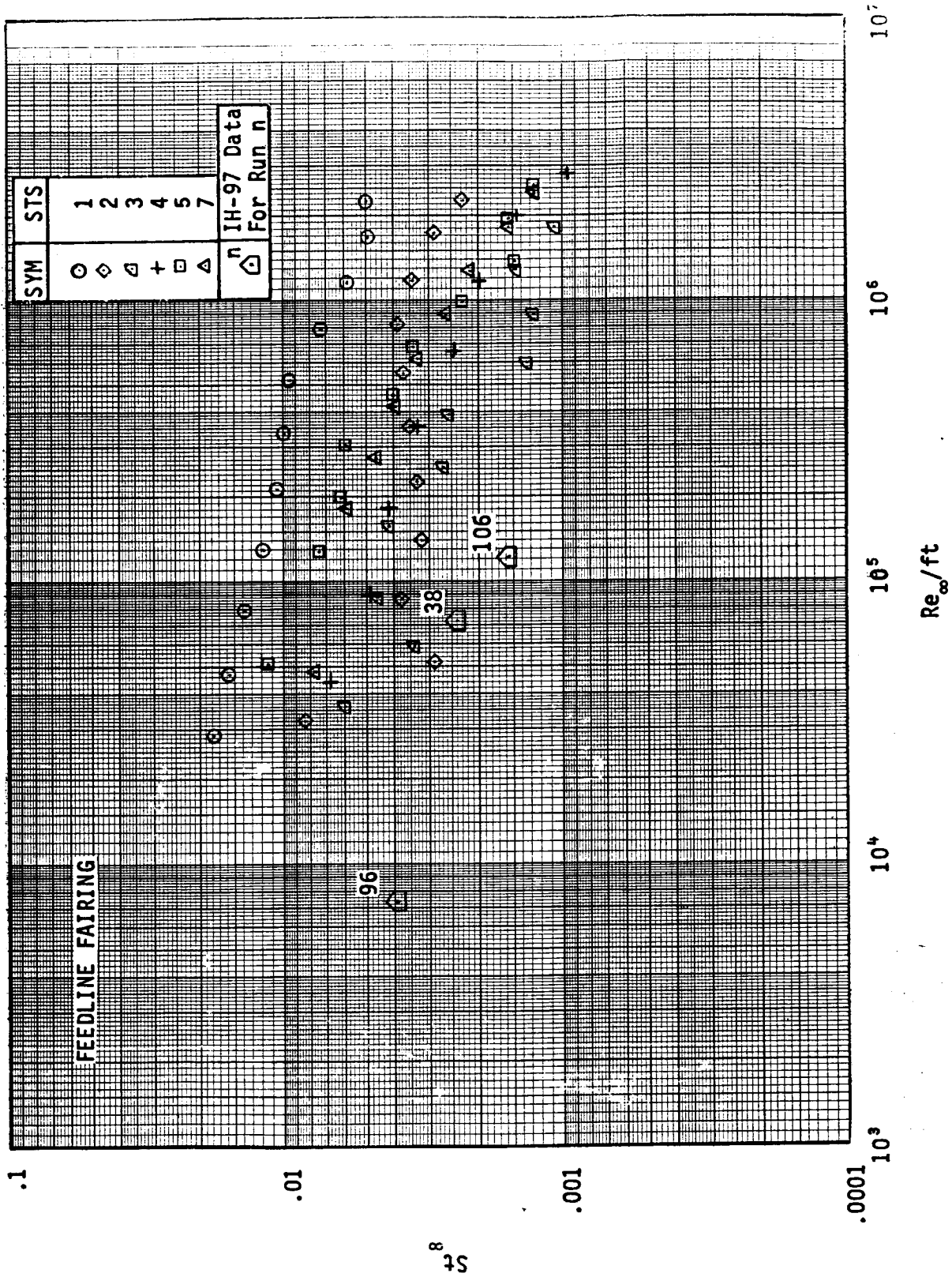


Fig. 20 Stanton Number As A Function Of Reynolds Number For Feedline Fairing

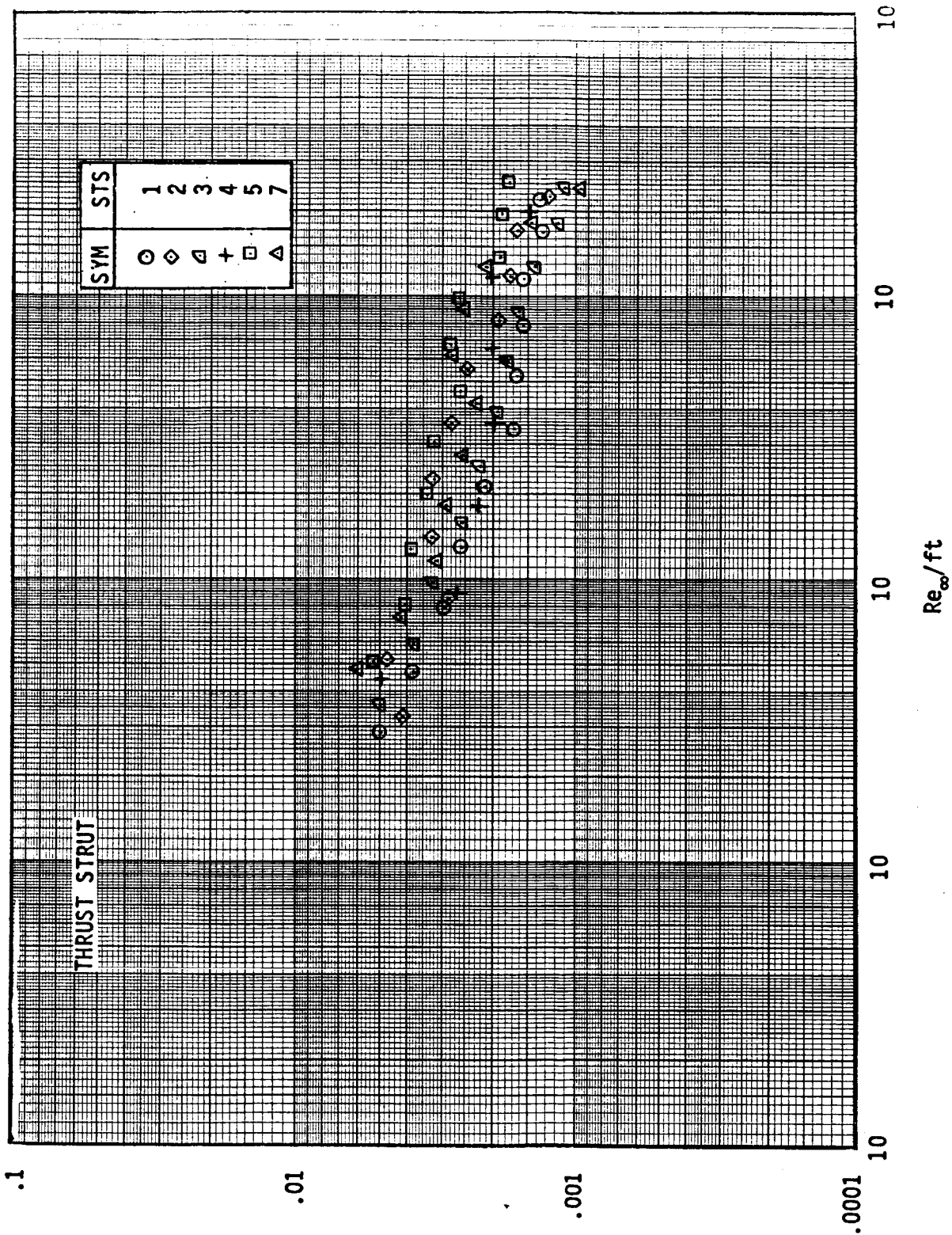


Fig.21 Stanton Number As A Function Of Reynolds Number For Thrust Strut

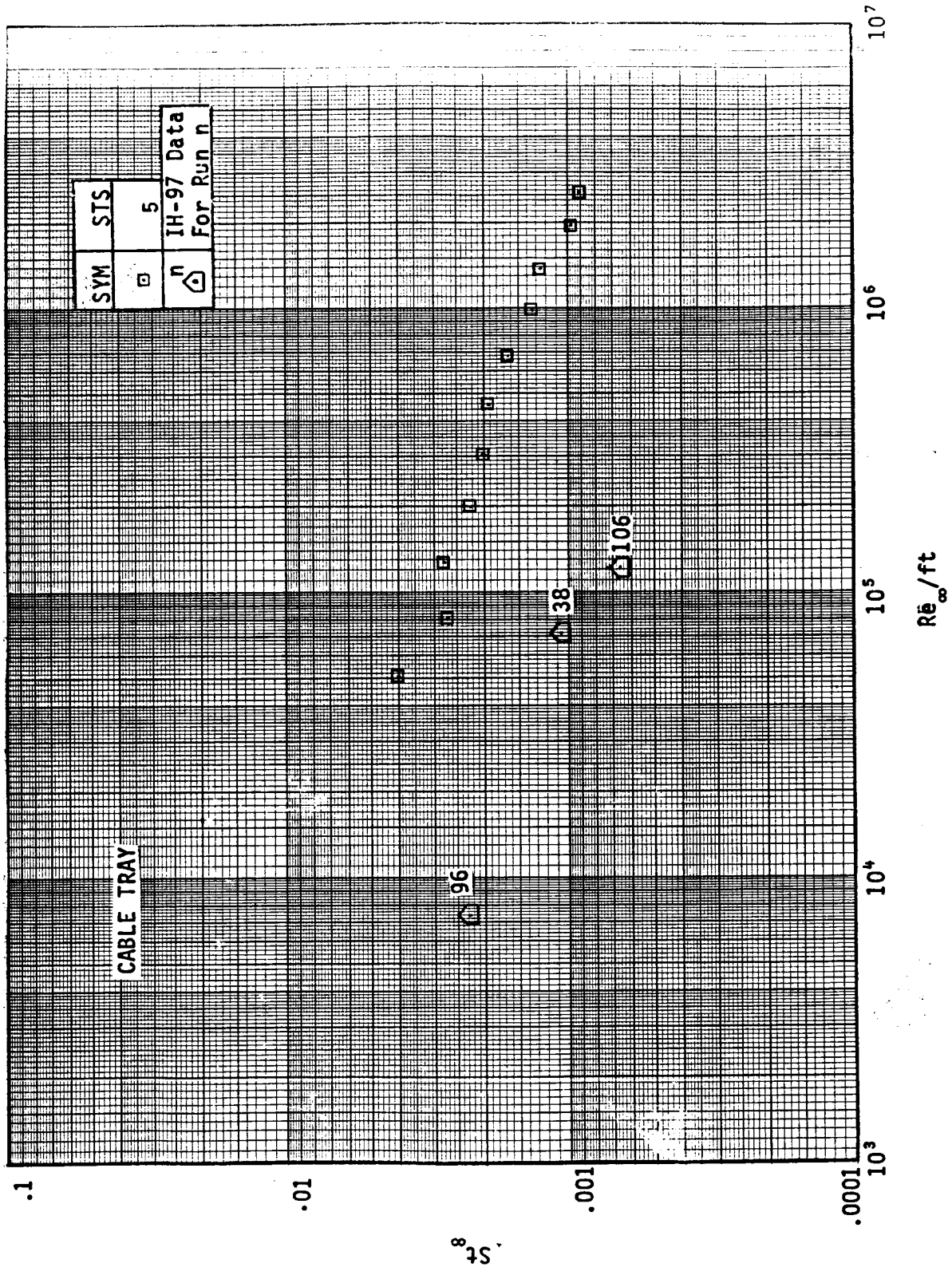


Fig. 22 Stanton Number As A Function Of Reynolds Number For Cable Tray

REMTECH INC.

APPENDIX E

FLIGHT-DERIVED HI/HU TABLES

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3.5043 3.6585 2.9639
0. 1 2 15.

3.6935 3.5495 3.4414 3.6208 3.0049
0. 2 0. 1 1. 3 2. 2 15.

3.5954 3.5524 4.0485 3.9073 3.4748
0. 1 2. 3 0. 1 7. 3 0. 1

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OF POOR QUALITY

-6AGE 9012 MI/HU-AT MACH 2.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RETA *

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1.3763 1.3779 2.8152 2.4136
0. 1 1 2 3 2 1 2

.00

1.2905 1.3620 2.1649
R. 3 4. 2 16. 4

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4.0345
23. 5

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2.1026 1.0425
0. 1 6. 3

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GAGE 9012 HT/HU-AT-MACH -3-00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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1.9596 1.8599 2.2897

1.9876 3.1067 2.8761

2.6516 2.0293 5.6123 5.6580

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GA5E 9012 HI/HU-A7-MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA *

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2.7938 2.5467
0. 1

.00 2.3701 2.3603 3.7271 3.0600 2.5970 7.0022 3
13. 5 7. 4 3. 3 0. 1 7. 4

1.00

3.0835 5.9324 9.3390
3. 3 0. 1 1. 2

2.00

3.0979 5.4630
1. 3

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PAGE 9012 HI/HQ AT MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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3.1049 3.2253 2.1628
0. 1 0. 2 12. 4
3.1930 2.8532 3.1105 2.6368 2.2499
7. 2 0. 1 3. 3 22. 2 29. 4
3.7049 3.5913 2.1736 2.1810 2.0409
0. 1 5. 3 0. 1 3 0. 1

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GAGE 9013 HJMU AT MACH 2.50

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* ALPHA *
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4.5908 3.7458 3.0987 3.3105
0. 1 0. 2 1. 2 2. 2

3.6331 3.4862 2.7649
4. 3 6. 2 9. 4

3.7041
15. 5

8.9904 8.4529
0. 1 6. 3

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0A6E-9013 HI/MU-AT MACH 3.00

* * * ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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5.0284 5.9126
0. 1 6. 3

4.2050
3. 4

.00

4.0116 3
1. 3

3.7495
2. 4

4.1893
0. 1

1.00

4.8250 5.2351
0. 1 7. 4

2.00

11.4315 10.3593
0. 2 2. 3

3.00

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646E 9013 HI/HU-AT-MACH-3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RETA *

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6.3582 6.0751

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4.9257 6.2639 4.6425 4.4079 4.2570

8.0950

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2. 5 3. 4 1. 3 0. 1 16. 4

7.4394 8.1624

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11.5007 1. 2

0. 1 3. 2

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11.5680 6. 3

* * * * * ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00 * * * * *

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7.0052 6.9833 6.7713
0. 1 0. 2 6.

.00

7.7508 8.9168 7.2071 7.5653 6.9223
5. 2 0. 1 11. 3 10. 2 16. 4

1.00

7.4630 7.4962 8.8372 8.5851 8.5432
0. 1 2. 3 0. 1 4. 3 0. 1

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6AGE 9014 NI/WU-AT-MACH 2.50

ALPHA

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3.4508 3.3443 3.1264 3.5758

0. 1 1. 2 1. 2 1. 2

4.1682 3.7185 3.8954

3. 3 13. 2 11. 4

4.6676

6. 5

3.9170 3.5985

0. 1 5. 3

SAGE 9014 HI/HU-AT-MACH 3.00

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BETA *****

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5.0330 4.7909 4.4031
0. 1 2. 3 3. 4

5.9847 5.4007 4.7499
2. 3 2. 4 0. 1

5.4260 5.3499
0. 1 2. 4

5.3536 5.0130
1. 2 3. 3

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OF POOR QUALITY

6AGE 9014 MT/MU-AT-MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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5.7955 5.9775
0. 1

7.4558 5.7187 6.3012 6.1462 5.8679 6.0896
3. 5 1. 4 2. 3 0. 1 3. 4 1. 3

6.6505 5.8877 6.2857
0. 3 0. 1 1. 2

6.5410 5.8161
1. 2 1. 3

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9.7881 9.4530 8.2244
 0. 1 1. 2 3. 4
 11.2490 10.3060 9.3256 9.1197 8.4080
 5. 2 0. 1 5. 3 0. 2 5. 4
 11.4700 11.1920 9.3300 9.5516 9.3646
 0. 1 3. 3 0. 1 1. 3 0. 1

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GAGE 9015 HI/HU AT MACH 2.50

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* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RETA *

-3.00

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9.7044 8.7527 6.7432 7.5098
0. 1 4. 2 3. 2 2.

.00

6.8017 7.5538 5.7474
4. 3 8. 2 8. 4

1.00

6.7738
10. 5

2.00

8.5546 7.6774
0. 1 4. 3

3.00

GAGE 9015 HI/NU AT MACN 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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15.1030 14.2973
0. 1 2. 3

11.0515
0. 4

.00

9.7430
3. 3

8.9018
5. 4

11.9790
0. 1

1.00

10.5100 11.1540
0. 1 4. 4

2.00

11.3120 12.4143
2. 2 3. 3

3.00

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OF POOR QUALITY

GAGE 0015 H1/HU AT MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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21.9750 15.5840
0. 1

.00

13.6460 20.7150 12.4400 11.6630 15.7742 18.9770
5. 5 3. 4 3. 3 0. 1 4. 4

1.00

18.0033 16.6800 20.6120
2. 3 0. 1 2. 2

2.00

16.6750 15.5713
2. 2 3. 3

3.00

GAGE 9015 HI/HU AT MACH 4.00

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6AGE 9016 H1/HU AT MACH 2.50

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BETA

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4.6901 4.5319 13.4745 14.7185
0. 3 2. 2 1. 2 3. 2

.00

4.7790 4.6253 11.2830
5. 3 6. 2 10. 4

1.00

5.7912
46. 5

2.00

11.3390 10.7713
0. 1 3. 3

3.00

0AGE 9014 HIGHU AT MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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6.4615 6.0972 20.3235

.00

14.0635 22.3240

1.00

5.9136 6.1870

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14.4405 16.1347

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ORIGINAL PAGE IS
OF POOR QUALITY

GAGE 9016 HI/HU-AT MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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6.8692 28.2500
0. 1 0. 1

.00

7.7096 6.9176 21.4777 21.4050 28.3370 6.8013
3. 5 1. 4 1. 3 0. 1 3. 4 2. 3

1.00

19.1583 6.5755 7.2743
0. 3 0. 1 0. 2

2.00

19.0330 6.5344
0. 2 0. 3

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11.1640 10.7750 26.1502

11.7615 11.4730 10.2893 21.0355 20.0082

11.7050 11.7437 31.3840 31.4757 31.7240

ORIGINAL FACE IS
OF POOR QUALITY

GAGE 9017 HI/HU AT MACH 2.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RETA *

-3.00

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2.0667 1.9961 1.9385 1.8697
0. 1 0. 2 1. 2 2. 3

.00

1.5265 1.0202 1.6277
4. 3 13. 2 12. 4

1.00

1.8806
9. 5

.00

2.1293 1.9637
0. 1 7. 3

3.00

GAGE 9017 HI/MI-AT-MACH -3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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1.9987 2.0291
0.1 0.3

1.3218
2.4

.00

1.6606
1.3

1.6765
1.4

1.2915
0.1

1.00

2.2155 2.0872
0.1 3.4

2.00

1.7048 1.5274
2.2 3.3

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040E 9017 MI/MT AT MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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GAGE 901A HI/HU-AT-MACH 2.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA *

-3.00

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7.0163 5.8892 8.7208 9.4532
0. 1 3. 2 2. 2 4. 2

.00

3.8212 4.5794 4.9753
4. 3 25. 2 55. 4

1.00

3.9319
12. 5

2.00

8.9846 8.3711
0. 1 6. 3

3.00

8AGE 9010 HI/HU-AT MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

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10.7360 9.9877

12.1005

.00

4.1180
1. 3

3.8434
2. 4

12.0280
0. 1

1.00

4.7195 5.1931
0. 1 7. 4

2.00

12.9070 11.6920
1. 2 3. 3

3.00

ORIGINAL PAGE IS
OF POOR QUALITY

GAGE 901A HI/HU-AT MACH -3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

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12.3470 16.8000

.00 4.9933 11.0325 4.5731 4.1396 17.5555 0.2144

1.00 2. 5 2. 4 2. 3 0. 1 19. 4 7.8246 8.5809

2.00 12.8117 13.1120 6.9912

3.00

6AGE 9010 HIGHU-AT-MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA

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7.3413 6.8490 6.7938
0. 1 1. 2 8.

.00

8.0926 9.0076 7.1937 7.7854 7.0826
5. 2 0. 1 12. 3 13. 2 18.

1.00

7.7376 7.8825 9.5400 9.3441 9.0799
0. 1 2. 3 0. 1 1. 3 0. 1

2.00

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ORIGINAL PAGE IS
OF POOR QUALITY

GAGE 9019 HISHU-AT-MACH-2.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

* BETA *

-3.00

-2.00

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2.7701 2.4324 2.6037 2.7479
0. 1 2 3 2 1 2

.00

4.7322 3.5150 2.5567
4. 3 33. 2 5. 4

1.00

3.3082
11. 5

2.00

3.6914 3.3409
0. 1 5. 3

3.00

6AGE 9019 HI/HU AT MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA

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3.6084

3.3755

3.6084

3.2430

9.9982

5.9304

3.2958

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GAGE 9019 NY/HU AT MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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4.0145 0. 1 4.2997 0. 1

6.5944 3.7787 3.3651 3.3133 4.6194 4.8841
1. 5 3. 4 1. 3 0. 1 17. 4 3. 3

4.8539 5.8074 7.0886
3. 3 0. 1 3. 2

4.9196 5.4501
1. 2 1. 3

GAGE 9819 HI/HU AT MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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9.3519 8.4884 4.6805
0. 1 2 3 4

.00

10.5035 11.1080 9.1261 7.3094 4.7137
3. 2 0. 1 11. 3 17. 2 15. 4

1.00

9.8489 10.0856 6.2602 6.2354 6.3195
0. 1 2 3 0. 1 1. 3 0. 1

2.00

3.00

ORIGINAL PAGE IS
OF POOR QUALITY

GAGE 9021 HI/HQ-AT-MACH 2.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RETA *

-3.00

-2.00

-1.00

1.0796 1.0341 .8766 .8354
0. 1 3. 2 0. 2 6. 2

.00

.8837 .9351 1.1526
6. 3 2. 2 8. 4

1.00

1.2859
5. 5

2.00

2.2102 2.0805
0. 1 3. 3

3.00

GAGE 9021 H7/HU AT MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA +

-3.00

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.9258
0. 1 .7480
n. 1

0.00

1.0569
6. 5 2. 4 3. 3 0. 1 3. 4
1.00 2. 4 3. 3 0. 1 3. 4

1.00

.9390
2. 3 .6871 .8666
n. 1 1. 2

2.00

.9136
1. 2 .6236
n. 3

3.00

GAGE 9021 HI/MU-AT MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

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.00

1.00

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3.00

1.1764 1.1305 1.1557
0. 1 1. 2 4.
1.1702 1.2330 1.2002 1.1073 1.1353
11. 2 0. 1 3. 3 1. 2 6.
1.0957 1.1415 .9708 1.0544 1.2365
0. 1 8. 3 0. 1 7. 3 0. 1

ORIGINAL PAGE IS
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GAGE 9022 HI/HU AT MACH 2.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA *

-3.00

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-1.00

1.8637 1.7121
0. 1 2 2

.00

1.8996 1.8310 1.5213
4. 3 7. 2 4. 3

1.00

1.8404
0. 5

4.00

1.5236 1.5238
0. 1 2. 3

3.00

PAGE 9022 HIGH-AT-MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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-2.00

-1.00

2.3939 2.3288
0. 1 1 3

.00

2.2075 2. 3 1.8698 2. 4

1.00

1.8007 1.7806
0. 1 2. 4

2.00

1.3925 1.3939
1. 2 1. 3

3.00

ORIGINAL PAGE IS
OF POOR QUALITY

GAGE 9022 HI/HU-AT-MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA *

-3.00

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1.6510
0. 1

.00

2.4335 1.0796 1.0363 1.0660
2. 5 5. 4 0. 3 0. 1

1.5419
1. 3

1.00

1.3744
1. 3

1.5304 1.6145
0. 1 0. 2

2.00

1.4246
0. 2

1.5129
1. 3

3.00

0A0E 9022 HI/MU AT MACH *00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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1.7AA2 1.9042 1.1759
0. 1 1 2 12. 4

.00

2.0527 1.8311 1.9591 1.4920 1.0717
5. 2 0. 1 A. 3 30. 2 17. 4

1.00

2.1765 2.1189 1.1549 1.0AA0 1.0242
0. 1 3. 3 0. 1 1. 3 0. 1

2.00

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ORIGINAL PAGE IS
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646E 002R H3/HU AT MACH 2.50

* ALPHA * -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

PETA *

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-1.00

.1916 .1922
0. 1 0. 2

.30

1.4192 .0511 1.0054
4. 3 77. 2 2. 3

1.00

2.0141
0. 1

2.00

.5064 .6304
0. 1 2. 3

3.00

GAGE 9025 HIGH AT MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA *

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-2.00

-1.00

.0924 .1818
0. 1 2 3

.00

.9670 2.1154
4. 3 2. 4

1.00

2.00

.0917 .0432
1. 2 57. 3

3.00

ORIGINAL PAGE 10
OF POOR QUALITY

6AGE 9025 MI/MU AT MACH 3.50

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* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00
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.0755
0.00

.00

1.2426 1.353 1.9330 2.0333
1. 5 4. 4 4. 3 0. 1

1.00

2.00

3.00

0A0E 9025 HI/MU AT MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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-1.00

1.4646 1.3980 1.3827

.00

1.5445 1.3456 1.3169 1.3025 1.4979

1.00

1.8071 1.6821 1.0320 1.2939 1.2224

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OF POOR QUALITY

GAGE 9026 HI/HU AT MACH 2.50

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1.1278 1.0807
0. 1 1 2

3.4748 2.2411 1.0249
3. 3 57. 2 3. 3

1.0424
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1.7095 1.7666
0. 1 2. 3

GAGE 9026 HIT/MS AT MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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1.2256 1.1851
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9.1337 1. 3 1.1934 1. 4

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2.0306 1.0945
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CASE 9024 HIZHI AT MACH 3.50

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4.3705 1.3644 1.3146 1.3011
1. 5 4. 4 1. 3 0. 1

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PAGE 9026 HT-MU-AT WAGH 4.00

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5.2518 5.1598 1.4396
0. 1 0. 2 3. 4
5.5401 5.3529 4.9744 3.3291 1.4413
1. 2 0. 1 4. 3 50. 2 4. 4
5.9015 5.5007 1.6119 1.5126 1.5608
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GAGE 9027 HI/HU AT MACH 2.50

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.3569 .0359
0. 1 0. 2

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2.0234 1.0079 2.0000
7. 3 64. 2 5. 3

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1.6916
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2.0093 1.0023
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616E-9027 HI/HU-AT MACH-3.00

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3.1193
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GA66 9027 HIGH-AT MACH 3.50

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GAGE 9027 H1/HU-A1 WACH 4.00

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GAGE 9028 HT/HU-AT WACH 2.50

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2.1026 2.1062 0.5025
2. 3 0. 1 6. 3

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5.5373
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0.7611 7.5925
0. 1 9. 3

3.00

040E 9020 HT/MU-AT HACH 3.00

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GAGE 9028 MI/MU AT MACH 3.50

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8AGE 9020 HI/HU-AT-MACH 4.00

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GAGE 9029 HI/HU-AT-MACH 2.50

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1.1561 1.1942 1.4149
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1.1702
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1.1742 1.1175
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PAGE 9029 MI/MU AT MACH 3.00

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1.4592 1.4542
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.9882 .8728
0. 3 4. 9

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1.2103 1.1104
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6AGE 9029 H3/HU-AT-MACH-3.50

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GAGE 9029 HI/HU-AT-MACH 4.00

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GAGE 903B NI/MU-A7 MACH 2.50

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.2107 .1018
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3.9006 2.0151 2.4448
0. 3 95. 2 11. 3

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2.7077
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4.1270 3.4232
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PAGE 0030 H17MU AT MACH 3.00

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4.3253
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5.0027
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6402 9838 HI/HU-AT MACH 3.50

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646E 9030 HI/HU-AT-MACH 4.00

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GAGE 9034 NI-HU AT-MACH 2-50

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.8561 .7801
0. 1 7. 2

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.02100 2.4190 3.0604
2. 3 80. 2 5. 3

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1.6414
92. 2

2.00

.00904 .03210
0. 1 10. 3

3.00

GAGE 9031 HI/MU AT MACH 3.00

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GAGE-9031 HI/HU-AT-MACH 3.50

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GAGE 9832 MI/MU AT MACH 2.50

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2.1111
A. 3

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2.2002
5. 5

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2.9275 2.7711
0. 1 7. 3

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6AGE 9032 HT/HU-AT NACH 3.00

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3.9647
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4.4500
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GAGE 9032 HT/HU-A7-MACH-3-50

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846E 9032 HI/HU AT MAEH 4.00

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GAGE 9038 HI/HU-AT MACH-2.50

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2.6098 2.5890 4.4376 4.8057
0. 1 2. 2 1. 2

3.1121 2.7643 3.4259
7. 3 16. 2 11. 4

5.0976
14. 5

2.0107 2.4151
0. 1 9. 3

616E 903A HI/MU-AT-MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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3.7461 2.3122
0. 1 7. 3

5.4459
2. 4

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4.1807
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5.3847
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5.6094
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5.4114
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5.0426 5.9988
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GAGE 903A HI/HU AT MACH 3.50

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5.9819 3.2989
0. 1 0. 1

5.2735 4.6520 7.4175 6.9802 3.3606 5.4219
21. 5 12. 4 3. 3 0. 1 6. 4 21. 3

1.00

10.0620
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4.2889 9.4551
0. 1 16. 2

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9.3341 3. 2

4.4396 1. 3

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* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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6.9904 7.2207 5.5066

.00

7.4373 6.4565 6.3167 6.6777 5.5020

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7.7701 7.6594 8.4968 8.0700 5.8512

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6AGE 0039 HI/HU AT MACH 2.50

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4.2673 4.2911 11.1955 12.8460
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4.6210 4.6328 5.3231
10. 3 3. 2 59. 4

1.00

9.7740
11. 5

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5.0006 5.1515
0. 1 5. 3

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PAGE 9039 HI/MU AT WACH 3:00

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9.1021 7.8562
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14.1837
0. 4

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8.2216
0. 3

6.2464
7. 4

14.1830
0. 1

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8.7422 9.4958
0. 1 4. 4

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7.7537 10.0127
7. 2 5. 3

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GAGE 9039 HI/HU-AT-MACH 3.50

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15.0460 14.9300
0. 1 0. 1

.00

15.3966 13.3632 9.9271 9.1974 15.5650 18.4500
10. 5 5. 4 4. 3 0. 1 7. 4 4. 3

1.00

15.9503 16.5960 19.0840
3. 3 0. 1 3. 2

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14.5345 15.0910
3. 2 4. 3

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6AGE 9839 --HI/HU-AT-MACH--4.00

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29.0910 28.6635 16.6907
0. 1 4. 2 10. 4

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28.1130 25.2650 24.5480 22.2675 18.0517
1. 2 0. 1 4. 3 16. 2 6. 4

1.00

27.8640 28.2063 22.0410 22.0937 19.7050
0. 1 4. 3 0. 1 9. 3 0. 1

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GAGE 9041 HI/HU AT MACH 2.50

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6.6986 6.0605 5.6129 7.0235
0. 1 1 2 2 2 2

.00

5.8324 5.8670 5.2067
9. 3 2. 2 6. 4

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7.1361
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7.1709 6.2002
0. 1 8. 3

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6A6E 9041 HI/MU AT MACH 3.00

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13.2310 11.9033

11.1742

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10.5675
6. 3

9.0016
7. 4

12.9300
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13.9210 15.9512

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10.5005 12.1643
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GAGE 9041 HI/HU AT WACH 3.50

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23.3510 1A.6760
0. 1

0.00

23.1616 21.3200 17.0707 15.6010 20.1162
14. 5 6. 4 6. 3 0. 1 5. 4 34.4747
5. 3

1.00

21.7903 30.8070 40.2440
3. 3 0. 1 1. 2

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19.2005 27.9843
2. 2 4. 3

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GAGE 9041 HI/HU-AT MACH 4.00

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GA6E-9042 NI/MU-AT-MACH-2.50

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2.5189 2.5677 7.3424 8.5452
0. 1 1 2 3 2

.00

3.6437 3.1983 4.3055
2. 3 18. 2 34. 4

1.00

3.2325
9. 5

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3.0132 3.4962
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GAGE 9042 HI/HU-AT-MACH-3.00

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3.2444 3.2196

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5.3147

16.5690

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4.7315 4.7564

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4.7007 4.7301

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GAGE 9042 HT/HU AT MACH 3.50

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4.0867 29.1830
0. 1

3.7611 4.0125 4.5030 4.7273 4.9135
2. 5 3. 4 3. 3 0. 1 10. 4

5.9378
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5.2939 7. 2

4.8406 4.2257
0. 1 0. 2

5.1539 1. 3

040E 9042 HI/MU AT-MACH 4.00

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4.4721 4.5136 5.4365
0. 1 1 2 4
5.7163 4.6895 4.3833 5.5937 5.7526
8. 2 0. 1 4. 3 21. 2 7. 4
6.5006 6.0369 7.4848 7.4211 7.0212
0. 1 4. 3 0. 1 13. 3 0. 1

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GAGF 9045 HI/HU-AT-MACH-2.50

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2.9719 3.5366 2.8119 2.6110
0. 1 4. 2 7. 2 1. 2

3.0612 3.0310 4.1240
3. 3 3. 2 19. 4

5.6805
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6.0696 4.9900
0. 1 10. 3

6AGE 9045 HI/HU-AT-MACH-3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

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4.9969 4.9500 2.6966

6.0325 7.1401 2.9862

7.3062 9.4240 9.6297 10.2577

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GAGE 9045 HT/MU AT MACH 3.50

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11.6800 0. 1 4.0173 0. 1

.00

11.0330 0. 5 10. 4 11.0373 10.0110 0.0975 17.5747 5. 3

1.00

13.3053 7. 3 16.5630 16.0070 0. 1 7. 2

2.00

12.4600 2. 2 15.0603 0. 3

3.00

GAGE 9046 HT/MU AT MACH 2.50

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5.9604 5.6988 3.2007 3.9248
0. 1 0. 2 0. 2 3. 2

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6.0544 6.4130 .7517
1. 3 7. 2 164. 4

1.00

.0391
0. 1

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17.7740 10.8023
0. 1 2. 3

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GAGE 9046 HITWU AT MACH 3.00

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0.1471 7.8444 5.4955
0. 1 1. 3 11. 4

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0.6440 2. 3 0.023 5.3733 0. 1

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13.3720 13.7140
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GAGE--9046--H17HU-AT-MACH--3.50

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GAGE 9046 HI/NU AT MACH 4.00

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13.7400 13.2270 .0221

0. 1 2. 2 103. 4

13.0410 11.0140 13.6127 7.1353 .0503

12. 2 0. 1 12. 3 99. 2 78. 4

14.7030 13.0530 .1505 .1459 .1299

0. 1 5. 3 0. 1 6. 3 0. 1

GAGE 9047 HI/HU-AT MACH 2.50

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11.9800 11.6050 6.4352 7.4076
0. 1 2. 3 2. 3. 2

.00

6.7817 0.4279 6.7592
2. 3 19. 2 0. 1

1.00

5.8438
3. 4

2.00

3.00

GAGE 9847 HI/MI-AT-MACH-3-00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

-2.00

-1.00

17.9080 15.8743

8.6376

.00

8.8214
3. 3

8.7252
0. 1

1.00

8.0545 7.8653
0. 1 10. 4

2.00

3.00

ORIGINAL PAGE IS
OF POOR QUALITY

GAGE 9047 HI/411 AT MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RETA *

-3.00

-2.00

-1.00

21.5210
0. 1

9.3850
0. 1

.00

13.0906 19.4760
4. 5 1. 4

9.8002
5. 4

.0732
0. 1

1.00

.3869
71. 2

2.00

3.7229
59. 3

3.00

080E 9047 H1/MU AT MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

-2.00

-1.00

9.6744 11.2550
0. 1 5. 2

.00

14.1265 12.2140 11.2020 9.5354
1. 2 0. 1 9. 3 0. 1

1.00

11.5530 12.8197
0. 1 9. 3

2.00

3.00

ORIGINAL PAGE IS
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GAGE 9020 HI/HU AT MACH 2.50

* ALPHA *
-4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

-2.00

-1.00

.00

3-7602 3-7045 4-4567
3. 3 0. 1 1. 3

1.00

4-4808
0. 1

2.00

4-5375 4-1250
0. 1 6. 3

3.00

CASE 9820 H1/HU AT MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA *****

-3.00

-2.00

-1.00

.00

5.1992
3. 3

4.7765
3. 4

1.00

2.00

5.7441 6.1564
5. 2 7. 3

3.00

ORIGINAL PAGE IS
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CAGE 9020 H3/HU-AT-WACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RTA *

-3.00

-2.00

-1.00

.00

8.0014 5.9674 5.7497
7. 5 4. 3 0. 1

1.00

0.2188
1. 3

2.00

0.1233
1. 2

3.00

GAGE 9020 HI/HU AT MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

-2.00

-1.00 11.3540 10.6900 9.0911

.00 10.8220 11.2100 10.7730 10.7400 9.8319

1.00 10.5180 10.5957 12.3900 11.9813 11.2070

2.00

3.00

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6AGE-9023 HI/HU AT-MACH 2.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RETA *

-3.00

-2.00

-1.00

.00

44876 3.8375 3.5340
7. 3 0. 1 6. 3

1.00

3.6897
0. 1

2.00

43725 4.1209
0. 1 7. 3

3.00

GAGE 9023 HI/HU AT MAGH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA

-3.00

-2.00

-1.00

.00

5.4230 5.2905
n. 3 n. 4

1.00

2.00

4.9132 4.6310
n. 2 n. 3

3.00

ORIGINAL PAGE IS
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CAGE 0023 H1/HU-AT MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00
* BETA *

-3.00

-2.00

-1.00

.00

7.4001 6.5369 6.4325
6. 5 1. 3 0. 1

1.00

6.5711
2. 3

2.00

6.2115
1. 2

3.00

0000 9023 01/01 AT MACH 400

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

9 TA

-3.00

-2.00

-1.00

.00

1.00

2.00

3.00

12.2750 12.0290 10.6190

11.2355 12.9480 11.6223 12.6445 10.9267

12.3250 11.8820 13.8680 13.5940 14.0540

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GAGE 0040 H1/HU AT MACH 2.50

5.00 6.00

4.00

3.00

2.00

1.00

.00

-1.00

-2.00

-3.00

-4.00

* ALPHA *

* BETA *

-3.00

-2.00

-1.00

.00

1.00

2.00

3.00

2.3493 2.2136
0. 1 3. 3

GAGE 9000 HI/HU AT WACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

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-1.00

.00

1.00

2.00

2.68031 2.6742
1. 2 0. 3

3.00

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SAGE 9040 WT/MU AT MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA +

-3.00

-2.00

-1.00

.00

1.00

3.5710
5 3

2.00

3.3094
1 2

3.00

GAGE 9048 HT/MU-AT-MACH 4.00

*
* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

RTA *****

-3.00

-2.00

-1.00

.00

1.00

2.00

3.00

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GAGE-9043 H7/MU-AT MACH-2.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

* BETA *

-3.00

-2.00

-1.00

.00

1.0153
4. 3

1.00

1.7721
0. 1

2.00

1.5114 1.5333
0. 1 1. 3

3.00

GAGE 9043 HI/HO AT MACH 3.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

-2.00

-1.00

.00

2.275
7. 4

1.00

2.00

1.0321 1-0067
1. 2 1. 3

3.00

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OF POOR QUALITY

GAGE 9043 HI/HU-AT MACH 3.50

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

BETA *

-3.00

-2.00

-1.00

.00

2.0902 2.0256
3. 3 0. 1

1.00

2.5308
3. 3

2.00

2.2007
2. 2

3.00

GAGE 9043 HI/HU AT MACH 4.00

* ALPHA -4.00 -3.00 -2.00 -1.00 .00 1.00 2.00 3.00 4.00 5.00 6.00

-3.00

-2.00

-1.00

3.1347

.00

3.4790 3.3007

1.00

4.2398 4.1038 3.6431

2.00

3.00

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NORMAL EXIT. CPU TIME: 53056 TOTAL SUPS: 173721 (MILLISECONDS)

PASG,T FILE,F//3000

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